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A NEW APPROACH TO WILDLIFE POSITION FINDING TELEMETRY[1]

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ABSTRACT

Wildlife position finding telemetry traditionally uses direction finding methods. These methods usually involve continuous transmitter broadcasting and the coordination of receivers. They are relatively inaccurate and cannot be adapted readily to automation. On the other hand, range finding methods are inherently suited to wildlife position finding telemetry. They require very brief transmitter "on" times, are more accurate and are readily automated. The hyperbolic approach to position finding is especially suitable. Here, transit of the signal from the instrumented animal is timed over three separate courses, one direct and two via automatic repeaters. Evaluation of the time delays from the two repeaters provides a two-dimensional estimate of position. By using recently developed long-term electronic timers, extended "off" time is possible. Brief "on" times permit powerful long-range transmissions with instrument longevities approaching battery shelf life. Animal-mounted instrument packages, small in size and light in weight, are possible. The system presented is similar to the more familiar Loran method of marine navigation, except that the unknown location transmits energy to the position-finding station.

As of 1969, there were but 35 scientific articles concerned with the location of instrumented animals by radio telemetry. Of these, all but one (Patric et al., 1965) dealt with position location by means of triangulation using two direction finders on a known baseline. Direction finding is nearly as old as radio, since early experimenters such as Hertz observed the directional properties of loop antennas. During

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The authors gratefully acknowledge the guidance and inspiration of Dr. Andrew Longacre in developing and testing the technique herein described. Thanks are due to Albert Hall, Ralph Colson, Joseph Dell and Stuart Free of the New York State Department of Environmental Conservation who provided sustained cooperation and support. The cooperation of Dr. Donald F. Behrend of the State University College of Forestry at Syracuse University is acknowledged. Special thanks are due to Charles Maddison and Adelard Boyer for their skill and energy. The article is written in memory of the late Joseph H. Gregory who provided continuing technical aid in the early phases of the project.

World War II the Adcock antenna was developed to overcome polarization error attributable to loops (U. S. Department of Army, 1944). With the advent of high-frequency communication, the directional properties of beam and yagi-type antennae became well known and were used by numerous telemetrists. Using still higher frequencies (above 50 MHz), yagis may be stacked to obtain more directive forward lobes. Patric et al. (1965) suggested the possibility of high-gain arrays of yagis stacked for gain and providing hybrid outputs for phase evaluation after the manner of Rhodes (1959). All of these methods provide an estimate of the direction of an unknown transmitter emission. To estimate location, two or more coordinated estimates of direction are required.

The accuracy of absolute position estimates, using direction finders, is based on the following factors:

1. the accuracy of the direction-finding estimates,
2. the distances between the transmitter and receivers, and
3. the angular relationship between the direction estimates.

The accuracy of a direction-finding estimate is based in turn on such factors as polarization error, path error, signal strength, site error, operator error, and so on (see U. S. Department of Army (1947) for a detailed evaluation of these factors). Since many of the factors involved are outside the telemetrist's control, the error may not only be considerable but also difficult to evaluate and control. To illustrate, a direction finder may be capable of providing an azimuth estimate accurate to within 3 degrees. Since this estimate is properly stated as ± 3 degrees, the possible error would be 6 degrees. Over a 2-mile course this error is equal to an absolute distance error of up to 1,110 feet. However, even this error is applicable only to the optimum situation where the estimates intersect at right angles. In most instances the estimates would intersect at an acute angle, causing the error to substantially exceed 1,110 feet.

Unfortunately, these are problems inherent in radio direction finding and are difficult to control. There are other problems. The absolute error increases with distance. For maximum precision, it is necessary to coordinate the work of two or more direction-finding stations so that determinations are made simultaneously at both. Since most direction-finding methods require substantial time and experience, they do not lend themselves to automation.

Efforts to overcome these problems have led to development of an improved position-finding method. It permits extended range and longevity in a small instrument package. Although the animal-mounted instrumentation is relatively simple, the system necessitates

more complex equipment at the position-finding station. Field tests have been carried on at the Huntington Wildlife Forest near Newcomb in Essex County (N.Y.).

The method involves the periodic emission of trains of short, powerful pulses from subject animals. The pulses arrive directly at the position-finding station, and also indirectly via two repeaters. Analysis of time delays, using hyperbolic methods, permits position determination. Analysis of pulse-rate frequency identifies individual animals. The entire system readily lends itself to automatic, unattended operation.

THE ANIMAL-MOUNTED INSTRUMENT PACKAGE ELECTRONIC TIMER

The method requires that the transmitter be "off" most of the time. This conserves battery energy and reduces the probability of simultaneous transmissions from two animal subjects. In the "on" condition, high-frequency, high-power transmissions penetrate environmental obstacles and provide the desired position information. Therefore, it is necessary that a timer provide the desired program of "off" and "on" conditions.

With the advent of the programmable unijunction transistor, the construction of a long-term timer became possible. This transistor was selected for its exceedingly low leakage current and low peak point current. The General Electric Company's D13T2 is well suited to the requirement. A suitable circuit is presented in Figure 1. The com-

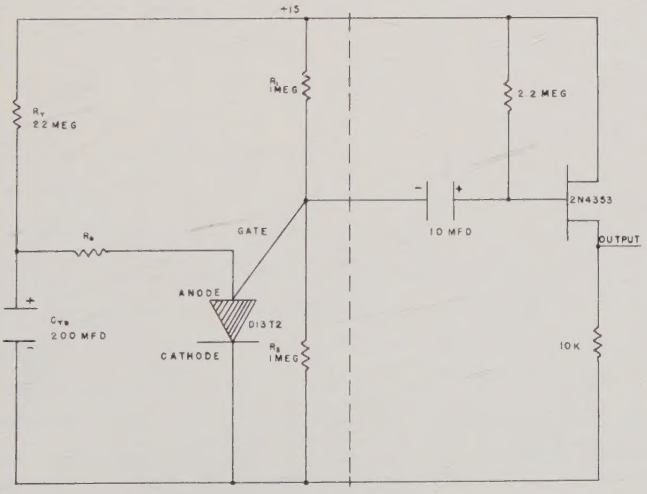

Figure 1. Schematic diagram of electronic timer. Component values shown provide 1 hour "off" and 2 seconds "on". Circuitry to the right of dashed line provides buffering and positive-going, low-impedence output.

ponent values shown provide 1 hour of "off" and 2 seconds of "on" time. This represents a 1/1800 duty cycle although many other combinations and ratios are possible. In the schematic diagram, the resistor (R_T) and capacitor (C_{TD}) control the "off" time, while resistors R_1 and R_2 set the firing point of the transistor. Operating voltage and temperature are not critical, although best results are obtained from 10 to 25 volts with the illustrated circuit.

In operation, C_{TD} is slowly charged through R_T. When C_{TD} is charged to a voltage 0.6 volt above the gate voltage (established by R_1 and R_2) the transistor fires. In this condition both the anode and gate are pulled down to cathode potential. This causes C_{TD} to discharge, but the discharge can occur only through another resistor (R_D). Therefore, R_D can be used to regulate the "on" time. When C_{TD} is discharged, the transistor ceases conduction and the cycle starts anew. The length of the "off" condition is determined by the values of R_T and C_{TD}. Since there is practically no leakage involved, R_1 and R_2 can be 1.0 to 2.2 megohms each, making maximum current drain in the "off" condition 7 microamperes using a 15-volt power supply.

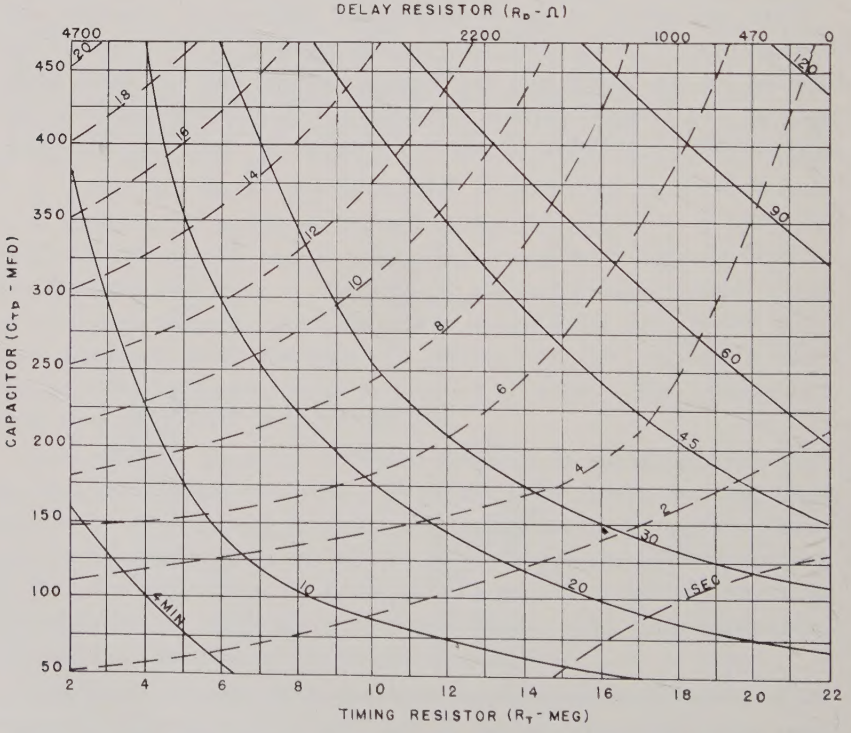

Figure 2. Selection of R_T, C_{TD} and R_D values for various "on" and "off" times. (see text for explanation of figure use)

The circuitry shown to the right of the dashed line in Figure 1 provides a useful low-impedance, positive-going output. Because an output taken from the junction of R_1 and R_2 has high impedance, a high input impedance field effect transistor is used to convert the timer into a more useable circuit. The 2N4353 is a P-channel silicon insulated-gate transistor selected for this application, although other types also may be employed.

Figure 2 provides the information necessary for selecting values of C_{TD}, R_T and R_D. First, select the desired "off" time and note the appropriate curve in Figure 2, interpolating as necessary. Then select the desired "on" time curve and note where the "off" time and "on" time curves intersect. From this intersection read coordinate values of C_{TD} to the left, and R_T values below. Follow the "on" time curve to the top of the figure and read the R_D value. Unusual ratios of "off" and "on" times outside the limits shown will require feasibility experimentation. To achieve these values, C_{TD} must be a low-leakage high-quality tantalum electrolytic capacitor, and R_T must be 1 megohm or greater except at low voltage.

In the system under consideration, the 1 hour of "off" time and 2 seconds of "on" time are achieved by a C_{TD} value of 200 microfarads, an R_T value of 22 megohms and an R_D value of 0 ohms. This results in a battery power savings factor of 1/1800 at the expense of an electronic timer drain of only 100 microwatts of power.

PULSERS

During the 2 seconds of "on" time it is desired that a train of pulses be produced for an individual animal which is unique for that animal. Thus, one animal might produce pulses at a frequency of 400 per second, one at 500 per second, and so on. The number per second must be reasonably stable so as to positively identify the animal as a particular individual.

Each pulse should possess a duration of 1 microsecond with a rapid rise and fall time in the order of 10 nanoseconds or less. After some experimentation, it was found that excellent pulses could be obtained from a United Transformer Company PIP-11 blocking oscillator transformer, although many other pulse-forming methods are suitable. It can readily be seen that a pulser producing 400 pulses of 1 microsecond duration would have a duty cycle of 1/2500 because there are 2,500 microseconds between each 1-microsecond pulse required to produce a frequency of 400 per second. Since these pulses ultimately control the transmitter, the transmitter "on" time would be only 0.019 second per day or only about 7 seconds per year. In this way excellent battery power conservation can be obtained and high transmitter power and long transmitter life can be considered.

It should be noted that radio transmitters used in wildlife telemetry are crystal-controlled. Since crystals may require a few milliseconds to come up to normal operation, it is not reasonable to "key" the entire transmitter with miscrosecond pulses. Instead, the crystal oscillator stage is operated for the entire 2 seconds of "on" time or for about 5 hours per year. The pulser circuit also operates on this regimen. In the radio-frequency transmitter, the stage following the crystal oscillator is modulated or "keyed" with the 1-microsecond pulses. All subsequent stages are operated Class C to avoid further control requirements and to assure that no current is consumed when the crystal oscillator stage is "off".

Transmitter

The radio transmitter design is generally straight-forward in accordance with accepted solid-state practice for VHF and UHF broadband applications. In short-pulse work one must employ high frequencies for legal operation. High frequency also permits an efficient antenna of reasonable size on the animal-mounted instrument package. The employment of short pulses with rapid rise and fall times also requires high frequency. broadband practice.

In natural environments where dense vegetation is common, high-frequency signals suffer greater attenuation than low-frequency signals over the same course. Therefore, although high frequencies are desirable for numerous reasons, there is a point where high frequency is no longer practicable. In addition, at approximately 1 gigahertz, a radio transmitter in dense vegetation no longer resembles a "point source" to detection equipment. For this study, the principal tests were conducted at 230 to 250 MHz which appears to be a desirable operating frequency range.

At lower frequencies, vegetation was demonstrably less effective in attenuating a signal. A series of tests were conducted at six frequencies between 18 and 150 MHz to ascertain the effects of vegetation intervening between transmitter and receiver antennae. These tests were run in July over selected 100-foot courses of dense vegetation representing "worst case" conditions encountered. The results, derived from the means of eight separate trials of each frequency in each vegetative type, are presented in Table 1.

Tests were confined to these frequencies to accommodate the Measurements Corporation Model 58 field strength meter used. The results suggest that attenuation due to vegetation increases with frequency. However, at higher frequencies beyond the ground wave region, losses are not intolerable. Obviously it is necessary to elevate receiver antennae to avoid vegetative attenuation as much as possible.

TABLE 1. RADIO SIGNAL ATTENUATION (IN DECIBELS) AT SIX FREQUENCIES THROUGH 100 FEET OF DENSE HARDWOOD AND SOFTWOOD VEGETATION

Frequency (in MHz)	Vegetation	
	Hardwood	Softwood
18	2.9	3.5
30	7.2	7.3
52	7.6	16.4
88	3.5	13.3
110	8.6	19.4
150	11.1	13.3

For this study all receiving apparatus was located atop mountains 2,200 to 2,800 feet above sea level, in relation to a baselevel on the area of some 1,400 to 1,800 feet, to provide the necessary relief from vegetative attenuation. Tests showed that 1 watt of radio-frequency power would readily cover the area under consideration, a circular basin of 15 square miles. These power levels are entirely realistic because the radio transmitter is "on" only several seconds per year. The antenna used was an end-fed whip approximately 10 inches long. Batteries for all equipment were of the alkaline type to provide high energy delivery at all operating temperatures.

For a 250-MHz transmitter, best results were obtained using fifth-overtone 62.5-MHz crystals in a series-tuned oscillator. High-frequency silicon epitaxial transistors such as 2N3866 make useful oscillators. This stage was followed by two 2N3553 doublers, the first of which was keyed or modulated with 1-microsecond pulses. A 2N3553 or similar transistor then followed as a "straight through" amplifier. An alternate approach which may be considered is that of a seventh-overtone 83.333-MHz crystal oscillator followed by a single-keyed tripler and suitable straight-through amplification. Crystal oscillators over 100 MHz are not recommended. Crystal oscillators much under 62.5 HMz result in unnecessary frequency multiplication and harmonic suppression problems.

THE POSITION-FINDING STATIONS

The constant speed of the electromagnetic wave front is 186,000 miles per second, or approximately 1,000 feet per microsecond. By measuring the time required for a signal to reach the receiver, the distance between transmitter and receiver can be determined. Accuracy tends to be controlled by design or by quality of the receiving equipment.

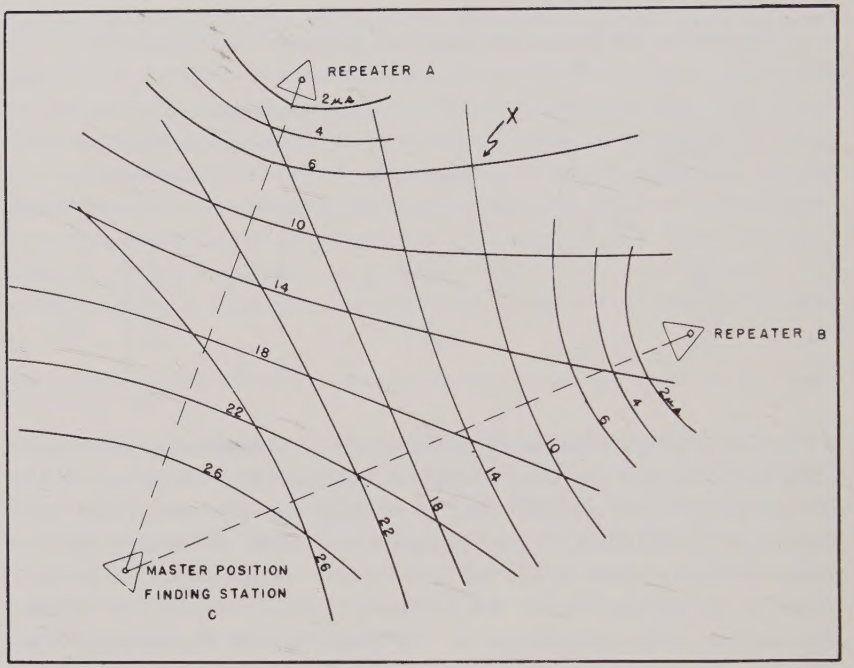

Figure 3. Arrangement of repeaters and master position-finding station to illustrate transmitter location using hyperbolic principle.

When a short-pulsed signal is emitted from a transmitter and proceeds to a receiver over two or more separate courses, a hyperbolic relationship exists in a plot of the signal arrival times. The hyperbolic principle is illustrated in Figure 3 in which "X" is the location of the radio transmitter, "A" and "B" are repeater or "slave" stations and "C" is the master position-finding station. When a short pulse of radio-frequency energy is transmitted from "X", it proceeds directly to "C". It also is received by "A" and retransmitted on a new frequency to "C". Unless "X" is on an extension of line CA beyond A, there is a time delay in the arrival of the signal from "X" to "C" via "A" compared with that of the signal transmitted directly from "X" to "C". The amount of this time delay places "X" on one of a family of hyperbolic curves between "C" and "A". The maximum possible time delay occurs when "X" is on an extension of line AC beyond C, and the amount of the delay is exactly twice the transit time between "A" and "C". A similar family of hyperbolic curves can be plotted between "B" and "C". When a signal arrives directly from "X" to "C" and then from "X" to "C" via "B", one of the hyperbolic curves plotted about line BC is identified. Since two hyperbolae plotted in this manner can cross at only one point, the

position of "X" can be determined precisely. This assumes a two-dimensional characteristic of the area covered, and is satisfactory for most applications. A system of three repeaters provides a three-dimensional solution which would best be accomplished by computer and could be useful for positioning airborne transmitters.

As illustrated in Figure 3, if a 6.0-microsecond time delay were obtained via "A" and a 10.0-microsecond time delay via "B", the transmitter ("X") must be at the intersection of the two hyperbolae involved. The accuracy of the determination is based on

1. the ability to resolve time,
2. the pulse rise and fall times, and
3. the angle of the hyperbolic intersections.

Since modern counters can resolve time delays to 10 nanoseconds (1/100 microsecond), a theorectical accuracy of ± 10 feet is possible. Obviously, system accuracy would fall short of this theorectical level. Points 1 and 2 are under the immediate control of the electronics designer. Point 3 can be partially controlled by system layout.

REPEATERS

The repeaters should be located on mountains, high promontories or elevated structures. The receiving antennae must be designed for broad lateral coverage of the entire area of interest. In a yagi antenna system, this would be the "H plane" parameter using the normal assumption of vertical signal polarization for the system. Medium-gain yagi antennae providing a gain of 10 to 12 decibels are satisfactory. An example of a pair of antennae providing the desired gain and "H plane" characteristic is the Taco Y-103 series. Two such antennae "skewed" will provide at least 100 degrees of horizontal coverage in two-dimensional systems while three will provide a full 150-degree coverage. As usual, doubling the number of antennae with suitable stacking provision will provide an additional gain of 3 decibels. Thus, four Y-103 antennae would provide a gain of 13 to 15 decibels and 100 degrees of horizontal coverage.

The repeater components should be all solid-state. Broadband receivers with low-noise F.E.T. "front-ends" are best. These should be followed by a low-noise mixer stage which is fed by a crystal-controlled local oscillator. The intermediate frequency should be at least 30 MHz with a 10-MHz bandwidth. Video output from the receiver may be used to key a multiplier stage on the low-power crystal-controlled transmitter. The crystal-oscillator stage must run continuously. The transmitting antenna should be directive and aimed toward the master position-finding station. Power for operation on remote mountain tops and in isolated locations can be supplied by liquid propane

gas-operated thermoelectric or wind-driven generators. This is especially convenient where the entire repeater is solid-state.

The two repeaters should be on separate transmitter frequencies at least 10 MHz apart. This distance between each repeating station and the master position-finding station should be known with great accuracy. This determination can be made with a geodimeter.

Master Position-Finding Station

The master station contains three separate broadband receivers. One is tuned to the signal from the transmitter at the unknown location and must be fed by a wide-coverage "skewed" antenna system similar to that already described for the repeaters. The other two receivers may be fed by simple directional antennae aimed at their respective repeater stations. The demodulation of the three incoming signals would result in video information similar to that shown in Figure 4. Here, the signal is examined on an oscilloscope

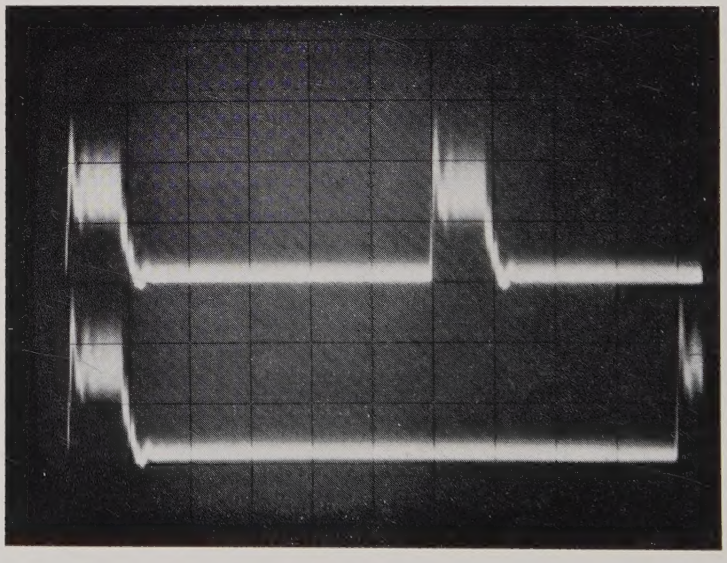

Figure 4. Dual-trace oscilloscope presentation of video information, representing 8 × 10 cm. screen with 1 μs/cm. sweep time. Input from transmitter starts both sweeps, initiating both left-hand pulses. The following pulses, from Repeater A (upper) and Repeater B (lower), are delayed by coming longer routes. Measurement of each of these delays, respectively, places the transmitter on a different line the intersection of which locates it.

and presented to clarify its character. The energy arriving directly from the animal-mounted transmitter triggers the oscilloscope sweep. The 1-microsecond video pulse presentations are delayed by 6.0 and

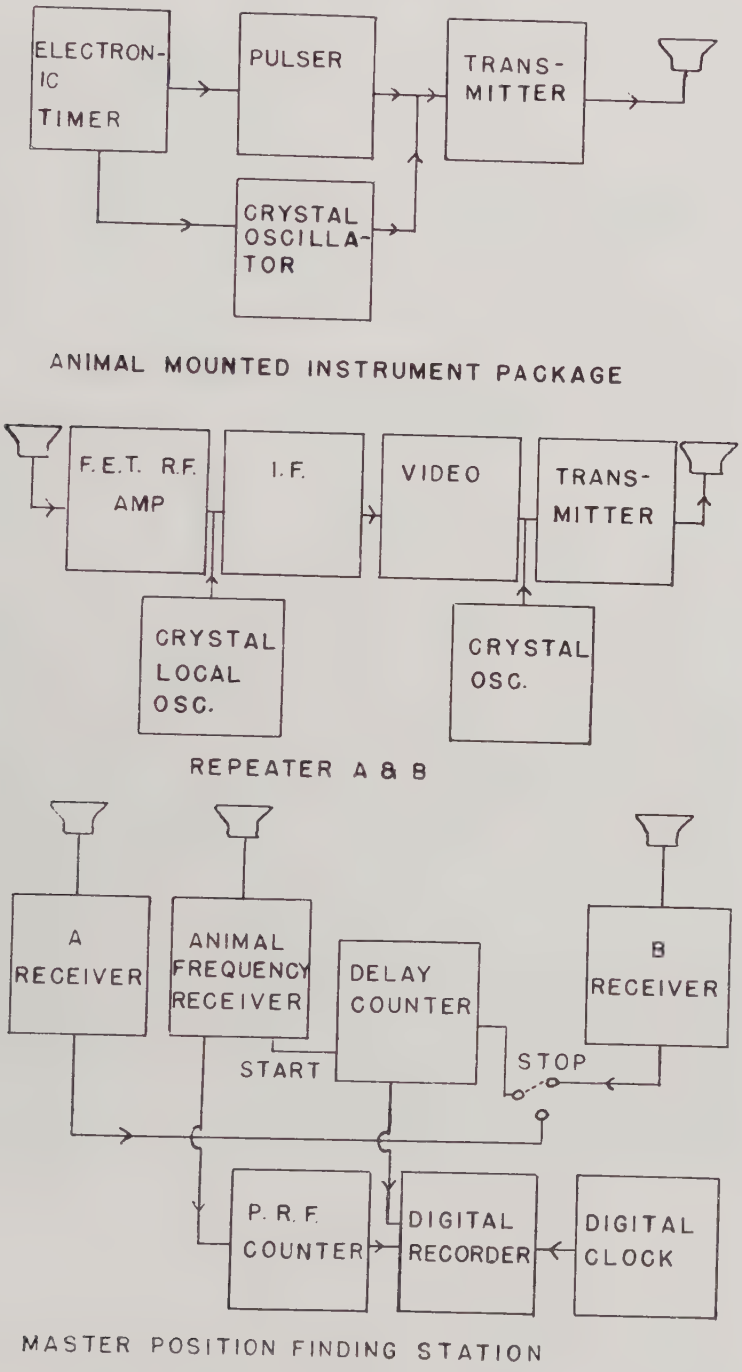

Figure 5. Operational diagram of position-finding system.

Figure 6. A suitable instrumentation lineup for the master position-finding station.

10.0 microseconds, the signals having thus arrived separately from "A" and "B" repeaters, respectively. The two delay determinations are all that is required to calculate the position of the transmitter. While oscilloscopic presentation is not recommended for accurate

determination of time delays, it is useful for testing and for demonstrating the hyperbolic principles involved.

In practical application, an unmanned master position-finding station is readily constructed and highly desirable. By starting an electronic counter with the video signal direct from the animal-mounted transmitter and stopping it with the repeater signal, a digital readout may be obtained. By employing a binary-coded decimal output on the counter and a digital recorder, a record can be permamently and automatically printed out. Gating first for one repeater, then the other, is recommended. A second electronic counter would provide a parallel entry recorder input that would identify the animal by counting its pulse-rate frequency. A digital clock on the recorder could supply simultaneous time-of-day information. Figure 5 shows an operational diagram of the position-finding system. Figure 6 illustrates a possible instrument selection to provide a high performance receiving and recording system.

DISCUSSION

Since each animal subject would be "on" 2 seconds out of each hour, there would exist a 1/1800 chance of two animals emitting signals simultaneously. As the number of animals increased, the probability of simultaneous emission would also increase. Thus, there is need for a method wherein coincidental signals would be rejected by the system. This would further reduce the problem of simultaneous emission from two transmitters.

Longevity of the animal-mounted instrument package is limited by total battery drain. The electronic timer section of the package draws 100 microwatts continuously from a 15-volt source. This amounts to 1 watt hour per year. The keying, pulsing and crystal-oscillator circuits draw an additional 45 milliamperes for about 5 hours per year, equalling 3.4 watt hours per year A 1-watt transmitter operating for 8 seconds per year at 50 per cent efficiency draws only an additional 0.01 watt hour. For this reason, the life of the instrument package is almost unrelated to transmitter power output. Approximately 3 cubic inches of battery, or 1 or 2 ounces of battery, could suffice for a year of service.

Since high current drains are briefly required from battery systems, the alkaline battery is preferred. Also, this battery can deliver high energy levels at low temperatures which may be encountered.

The range possibilities of the system are very considerable, as increases in radiated transmitter power have virtually no effect on battery power consumption. In the system under consideration, the transmitter works into a unity-gain antenna radiating approximately 1 watt of power. With 10- to 12-decibel receiving antennae on elevated

supports and with sensitive receivers, a range of several miles is readily obtainable. In order to double the range in a given system, an increase of 12 decibels would normally be required. This would alter the battery power consumption from 4.41 to 4.44 watt hours per year.

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COMPARISON OF SHORE-ZONE FISHES OVER NATURALLY VEGETATED AND SAND-FILLED BOTTOMS IN GREAT SOUTH BAY[1]

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ABSTRACT

Between May 1967 and November 1968, a total of 310 seine hauls were made at paired stations, representing naturally vegetated bottoms and sand-filled bottoms, at three sites in Great South Bay on Long Island. Collected fish were counted, measured and weighed to compare species composition over the two types of bottom. All sand-filled bottoms were created by the deposition of spoil from dredging operations. Most of the non-temporal variability in species composition could be attributed to differences between the bottom types. Of 40 fish species recorded, 23 clearly preferred one bottom type over the other. Most species preferred the naturally vegetated bottoms.

Dredging for navigational improvements, for beach replenishment, for land development and for removal of duck farm wastes has aroused much controversy on Long Island (N.Y.). Many have felt that the deposition of dreding spoil upon islands and marshlands has seriously degraded valuable fish and wildlife habitats (Anonymous, 1961, 1965; Clark, 1967; Gottschalk and Andrews, 1963). Bennett and Foehrenbach (1966) discussed potential public health hazards with regard to shellfishing and swimming when the spoil materials contain duck farm wastes and other materials with high coliform bacterial counts.

Few studies have been conducted on the effects of dredging and spoil deposition on estuarine fishes. Ingle (1952) was concerned primarily with dredges involved in dead shell reclamation in Florida. Hutton et al. (1956) studied Boca Ciega Bay in Florida with direct reference to dredging and filling. Thompson (1961) expressed alarm at the increased amount of dredging and filling in Atlantic coast estuaries. In their study of the Delaware River estuary, de Sylva et al. (1962) briefly discussed the problem. Cronin (1967) likewise touched only briefly upon dredging and filling. Harrison (1967), Biggs (1968) and Flemer et al. (1968) reported on various effects of spoil deposition in Chesapeake Bay, but not in the shore zone. Hollis (undated) re-

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viewed the detrimental effects associated with increased turbidity and siltation caused by dredging and filling operations.

Studies of estuarine fauna in the Northeast (Warfel and Merriman, 1944; Stickney, 1959; Pearcy and Richards, 1962; Jerome et al., 1965, 1966, 1967; Fiske et al., 1966, 1967; Mulkana, 1966) gave few data about the effects of dredging and filling, although they did give valuable data about the fishes and their relative abundance. In New York, the comments of Moore (1937) on dredging in the Hudson River may also be applicable to Long Island bays. Greeley (1939) expressed concern over environmental changes destructive to fish habitats in Long Island waters.

With continued pressure for increased dredging and filling operations on Long Island, and considering the paucity of information as to how these operations would or would not affect fish populations in shallow estuarine waters, the State Conservation Department undertook a study of the fish fauna of the shore-zone over both untouched areas of natural vegetation and sand-filled bottoms.

The present paper discusses the temporal distribution of shore-zone fishes over two bottom types in Great South Bay, sampled during 1967 and 1968. It also analyzes the variability in species composition with respect to time, bottom type, salinity and temperature. The "preferences" of particular species for these bottom types are discussed, and the influences of season and bottom type on species diversity in these fish communities are assessed.

DESCRIPTION OF STUDY AREA

The three islands in Great South Bay chosen as study sites (Figure 1) had in whole or in part been used as spoil areas. The fill, in addition to destroying wetland areas on the islands, had encroached upon the bay bottoms abutting the spoil areas. Thus, the waters around the islands had sand-filled bottoms adjacent to the natural bay bottoms.

The natural bottoms were a mixture of sand, clay, mud and detritus, with the clay and silt predominant. They were covered with a dense growth of eelgrass (*Zostera marina*) and associated epiphytic flora. Many forms of algae, such as sea lettuce (*Ulva lactuca*), *Enteromorpha* spp. and *Polysiphonia* spp., also were present in varying amounts and *Punctaria latifolia* was prominent each May. In the summer of 1967, the eelgrass became thickly entangled with the green alga, *Cladophora gracilis*, to the extent that at times seining could not be carried out. This alga was also common in 1968, but it was not dense enough to hamper seining operations.

The sand-filled bottoms consisted of a fine, hard-packed sand at

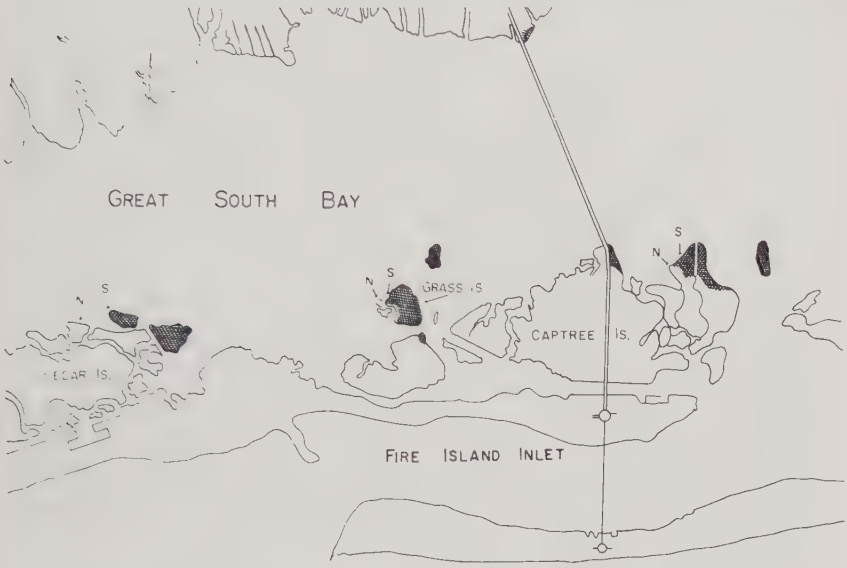

Figure 1. Map showing the three study sites. Crosshatched portions denote major sand-filled areas. Sampling stations at each site are indicated by "N" for natural bottom and "S" for sand-filled bottom.

Grass and Captree Islands. There were some soft, sticky spots at Captree Island (Figure 2) where silt and clay were mixed with the sand. At Cedar Island, the sand was also hard-packed, but coarser than that at the other islands. In general, the sand-filled sites lacked vegetation. In May, detached pieces of *Punctaria latifolia* were occasionally encountered in abundance. *Enteromorpha linza* was attached to small pebbles at the low-water line at Cedar Island in the fall of 1967 and the spring of 1968, but this growth was sparse. Also, at this site each fall, some small masses of *Polysiphonia* spp. were found floating about. As over the natural bottoms, thick masses of *Cladophora gracilis* floated in and made it impossible, at times, to seine the sand-filled bottoms in the summer of 1967. The only eelgrass on these bottoms consisted of detached and floating blades. Occasionally a few of these became sanded in, giving the impression of a sparse growth of the plant. Windrows of detached and decaying blades of eelgrass were found at the extreme high-water line at all sites.

The maximum depth at high water over the naturally vegetated bottoms ranged from about 4 feet (1.2 meters) at Cedar Island to about 3 feet (0.9 meter) at Grass and Captree Islands. There is little tidal amplitude over much of Great South Bay, and the maximum depths at low water were only about 1 foot (0.3 meter) less than those at high water. The depths over the sand-filled bottoms were similar

Figure 2. The sand-filled area at Captree Island. The natural-bottom station is in the background.

to those over the adjacent natural bottoms at Grass and Cedar Islands. However, at Captree Island the maximum depth at high water over the sand-filled bottom was only about 2 feet (0.6 meter), and at low water it was about 1 foot (0.3 meter).

METHODS

Seining was done at paired stations, i.e., over adjacent naturally vegetated and sand-filled bottoms, at Captree, Grass and Cedar Islands in Great South Bay (Figures 1 and 2). The sampling gear consisted of a 6 x 300-foot (with warp) (1.8 x 91.4-meter) nylon beach seine composed of 1½-inch (38.1 millimeter) stretch mesh in the wings, ¼-inch (6.4-millimeter) knotless mesh in the bunt and ⅛-inch (3.2-millimeter) knotless mesh in the bag. Using an 18-foot (5.5-meter) skiff, this seine was set in a pattern to conform as closely as possible to a rectangular encompassing 10,000 square feet (9.3 ares).

The effects of inclement weather and filamentous algal blooms limited seining to 65 of 75 randomly selected dates from mid-May to mid-October in 1967 and to 93 of 102 dates from May 1 to mid-November in 1968. No seining was planned or done in June of either year. Usually, seining was done at only one site (i.e., two stations) on any given day. In all instances, seining at a site was completed over both types of bottom within an hour to minimize influences of changes in tide, temperature and salinity.

The time at the end of each haul was recorded, and from this the tidal stage was determined from a published tide table using U. S. Coast and Geodetic Survey figures and correcting for the area seined. Immediately after each haul, water temperature (in degrees Fahrenheit) and salinity (in parts per thousand) at 1 foot below the surface were recorded using a Gemware salinity hydrometer kit (No. 1110/3) and copper hydrometer jar (No. 1115) with thermometer.

The captured fish were separated by species. If 100 or fewer individuals of a species were captured in one haul, all were measured to the nearest millimeter in total or fork length (dependent upon the conformation of the caudal fin) and weighed on a Hanson model 1411 dietetic scale to the nearest gram. If more than 100 individuals were taken, a random sample of 100 was measured and weighed. The number of specimens in the total catch was subsequently estimated by dividing the total weight by the average weight of the fish in the sample. If the total catch of a species weighed less than 1 gram, its biomass was determined by displacement to the nearest 0.1 milliliter in a 10-milliliter graduated cylinder. The gear used in weighing and measuring, together with a typical early season catch, is illustrated in Figure 3.

Figure 3. Typical early-season catch from the natural bottom-station at Grass Island (May 16, 1968). Note measurement gear.

RESULTS

The purpose of the present study did not require determinations of total numerical abundance of any species. Rather, it involved relative abundance in the two types of habitat, based on samples taken by comparable methods. Although fish as small as 8 millimeters long were captured by the seine, the authors believe that escapement was probability significant for most species at less than 15 millimeters.

The scientific and common names of the 40 species, representing 26 families, seined in Great South Bay during 1967 and 1968 are listed in Table 1. Nomenclature follows that of the American Fisheries Society (1970). Most of the families were represented by a single species. Only the Clupeidae, Cyprinodontidae and Gadidae contributed as many as four species.

Dominant Species Groups

Fourspine stickleback, Atlantic silverside and mummichog were the most numerous species in catches over natural bottoms (Table 2). Atlantic silverside, striped killifish, fourspine stickleback and sheepshead minnow were the most numerous in catches over sand-filled bottoms.

The dominance of various species of silverside, killifish and, in some instances, stickleback in shore-zone collections from Atlantic coast estuaries has been well documented. For example, Mulkana (1966) in Rhode Island found that ". . . five dominant species *Menidia menidia*, *Fundulus heteroclitus*, *F. majalis*, *Apeltes quadracus* and *Cyprinodon variegatus*" composed the bulk of his catches. Moreover, his catches of the fourspine stickleback occurred at a station with a dense growth of eelgrass, while his largest catches of the striped killifish were taken at a station with a silty sand bottom and sparse vegetation. Working in the Mystic River estuary in Connecticut, Pearcy and Richards (1962) found that "Beach seine catches were dominated by *Menidia* spp., *Fundulus* spp. and juvenile *P.* [*Pseudopleuronectes*] *americanus* although other forms such as *Apeltes quadracus*, *Gasterosteus aculeatus*, *Syngnathus fuscus*, *Cyprinodon variegatus* and *Opsanus tau* were common." Other authors, such as: Greeley (1939) on Long Island; Pearse et al. (1942) and Tagatz and Dudley (1961) at Beaufort, North Carolina; Warfel and Merriman (1944) in Connecticut; Gunter (1951, 1958, 1967) in the Gulf of Mexico; Shuster (1959) and de Sylva et al. (1962) in Delaware Bay; Mihursky and McErlean (1964) in the Patuxent River in Maryland; Pacheco and Grant (1965) in Delaware; and Jerome et al. (1965, 1966, 1967) and Fiske et al. (1966, 1967) in Massachusetts, found similar dominances of species of silverside, killifish and, in some instances, stickleback in their catches.

TABLE 1. SCIENTIFIC AND COMMON NAMES, GROUPED BY FAMILY, OF SPECIES OF FISH COLLECTED BY SEINING IN GREAT SOUTH BAY IN 1967 AND 1968

Anguillidae
Anguilla rostrata American eel

Clupeidae
Alosa aestivalis Blueback herring
Alosa pseudoharengus Alewife
Brevoortia tyrannus Atlantic menhaden
Clupea harengus harengus Atlantic herring

Engraulidae
Anchoa mitchilli Bay anchovy

Batrachoididae
Opsanus tau Oyster toadfish

Gadidae
Microgadus tomcod Atlantic tomcod
Pollachius virens Pollock
Urophycis regius Spotted hake
Urophycis tenuis White hake

Belonidae
Strongylura marina Atlantic needlefish

Cyprinodontidae
Cyprinodon variegatus Sheepshead minnow
Fundulus heteroclitus Mummichog
Fundulus majalis Striped killifish
Lucania parva Rainwater killifish

Atherinidae
Menidia beryllina Tidewater silverside
Menidia menidia Atlantic silverside

Gasterosteidae
Apeltes quadracus Fourspine stickleback
Gasterosteus aculeatus Threespine stickleback

Syngnathidae
Syngnathus fuscus Northern pipefish

Serranidae
Centropristis striata Black sea bass

Pomatomidae
Pomatomus saltatrix Bluefish

Carangidae
Trachinotus falcatus Permit

Lutjanidae
Lutjanus griseus Gray snapper

Sparidae
Stenotomus chrysops Scup

Sciaenidae
Bairdiella chrysura Silver perch
Menticirrhus saxatilis Northern kingfish

Labridae
Tautoga onitis Tautog
Tautogolabrus adspersus Cunner

Mugilidae
Mugil cephalus Striped mullet
Mugil curema White mullet

Sphyraenidae
Sphyraena borealis Northern sennet

Ammodytidae
Ammodytes americanus American sand lance

Triglidae
Prionotus carolinus Northern searobin

Table 1. (*continued*)

Cottidae	
Myoxocephalus aenaeus	Grubby
Bothidae	
Scophthalmus aquosus	Windowpane
Pleuronectidae	
Pseudopleuronectes americanus	Winter flounder
Ostraciidae	
Lactophrys triqueter	Smooth trunkfish
Tetraodontidae	
Sphoeroides maculatus	Northern puffer

Variation in Species Composition

It was hypothesized that most of the non-temporal variability in species composition among the six sampling stations was attributable to differences between the natural and sand-filled bottoms. It was also hypothesized that variability between the three islands was negligible in comparison with that between the natural and sand-filled bottoms at each island. These hypotheses pertain to variability in community composition. The study dealt with variations in proportionate composition, not with differences in numerical abundance or weight.

Since there was little variation between years, in contrast to seasonal variation, data for 1967 and 1968 were treated collectively. To minimize the influence of marked seasonal variation in species composition, data for each month were treated separately. The records for eight to 10 hauls from each station were processed for each month, except November when only two hauls had been made at each station.

An appropriate form of variance analysis for percentage composition was described by Krumbein and Tukey (1956). This analysis is ideally suited for evaluating the similarity among areas with respect to community composition.

The proportionate composition in each seine haul was calculated for the 11 most abundant species, i.e., Atlantic silverside, fourspine stickleback, striped killifish, mummichog, sheepshead minnow, northern pufer, northern pipefish, Atlantic needlefish, white mullet, striped mullet and threespine stickleback. The proportions made up by all other species were lumped in an "all others" category. These 12 proportions per haul were then arrayed in their appropriate positions in the sampling hierarchy, i.e., two bottom types at each of three islands and the maximum number of replicates available for each bottom type. The array is illustrated, with specimen data, in Figure 4.

Each proportion was then tranformed by taking the arcsin of its square root. While this "angular transformation" was not necessarily required for this analysis, it seemed appropriate for these data, based on the guidelines for its use given by Snedecor and Cochran (1967).

	CAPTREE I.		GRASS I.		CEDAR I.	
	SAND	NATURAL	SAND	NATURAL	SAND	NATURAL
SPECIES	Replicate 1 2345678 9	Replicate 1 2345678 9	Replicate 1 — 9	Replicate 1 — 9	Replicate 1 — 9	Replicate 1 — 9
Atlantic silverside	.73	.41 .39				
fourspine stickleback	.003	.002 .47				
striped killifish	.24	.57 .002				
mummichog	.02	.01 .14				
⋮	⋮	⋮				
⋮	⋮	⋮				
all other species	.001	.001 .002				

FISH – PROPORTIONATE SPECIES COMPOSITION

Figure 4. Schematic tabulation for August of proportionate species-frequency composition, before transformation, for Krumbein and Tukey analysis of variance. Only specimen proportions are entered for the frequencies of species; the complete August analysis involved three (islands) × two (bottom types) × nine (replicates) × 12 (species categories), i.e., 648 proportions.

The computations used to arrive at degrees of freedom and mean squares for F tests were described in detail by Krumbein and Tukey (1956). The mean squares for main effects, e.g., between islands, are of no interest in this analysis. Only the interaction mean squares between species and sampling levels are of interest. Interaction mean squares were calculated for islands x species, bottom types x species, and replicate hauls x species.

Using these mean square values, the F ratio of islands x species to bottom types x species was used to test the hypothesis that the variability in species composition between islands was not significantly greater than that between the natural and sand-filled bottoms at each island. This hypothesis was never rejected at the .05 significance level, on the basis of either weight or frequency of occurrence, for any of the six months.

The F ratio of bottom types x species to replicate hauls x species was used to test the hypothesis that the variability in species composition between bottom types was not significantly greater than that between replicate hauls. This hypothesis was rejected at the .01 significance level, on the basis of both weight and frequency of occurrence, for all months except November. It was also rejected for November at the .01 level on the basis of frequency of occurrence. Thus it is clear that throughout the spring, summer and fall most of the variability in species composition was related to the difference in bottom types.

Species Preference for Environment

A series of chi-square tests (Snedecor and Cochran, 1967) was run

Table 2. Species and Number of Fish Seined Over Natural Bottoms and Sand-Filled Bottoms of Great South Bay in 1967 and 1968

Species	Number	
	Natural bottom	Sand-filled bottom
Atlantic silverside	241,026	406,501
Fourspine stickleback	269,770	18,710
Striped killifish	1,734	87,339
Mummichog	49,134	7,540
Sheepshead minnow	2,480	14,991
Northern puffer	4,067	3,904
Northern pipefish	4,226	658
Atlantic needlefish	1,568	1,063
White mullet	166	2,411
Striped mullet	5	1,791
Threespine stickleback	1,960	9
Winter flounder	509	332
Silver perch	486	0
American eel	435	35
Northern kingfish	25	319
Rainwater killifish	324	16
Tautog	191	3
Oyster toadfish	168	26
Cunner	141	2
Atlantic herring	93	34
Tidewater silverside	59	66
Bluefish	63	46
Bay anchovy	31	9
Atlantic menhaden	26	14
Pollock	20	0
Blueback herring	19	0
Atlantic tomcod	17	0
Permit	2	5
Northern sennet	4	0
American sand lance	2	1
Windowpane	1	2
Spotted hake	3	0
Alewife	0	2
Gray snapper	2	0
Grubby	1	1
Black sea bass	0	1
Smooth trunkfish	1	0
Northern searobin	1	0
Scup	1	0
White hake	1	0
Total	578,762	545,831

to help assess the significance of species abundance over natural and sand-filled bottoms. The relative total abundance of each species is given in Table 2, and Table 3 gives the results of the tests. These tests overlook large seasonal variations in population density. However, they are helpful in assessing species preference for one bottom type or the other for all seasons combined.

Seventeen species preferred the natural bottoms (Table 3): four-

TABLE 3. SPECIES EXHIBITING A SIGNIFICANT PREFERENCE FOR ONE TYPE OF BOTTOM OR THE OTHER DURING THE TIME PERIOD OF CAPTURE

Preferring natural bottom		Preferring sand-filled bottom	
Species	Chi-square*	Species	Chi-square*
Fourspine stickleback	218,492.17	Atlantic silverside	42,301.93
Mummichog	30,525.24	Striped killifish	82,270.01
Northern pipefish	2,605.14	Sheepshead minnow	8,957.71
Atlantic needlefish	9.65	White mullet	1,954.03
Threespine stickleback	1,931.18	Striped mullet	1,774.07
Winter flounder	36.83	Northern kingfish	249.56
Silver perch	484.00		
American eel	338.73		
Rainwater killifish	277.20		
Tautog	180.25		
Oyster toadfish	102.48		
Cunner	133.17		
Atlantic herring	26.49		
Bay anchovy	11.03		
Pollock	18.05		
Blueback herring	17.05		
Atlantic tomcod	15.06		

*Significant at .01 level (chi-square >6.635).

spine stickleback, mummichog, northern pipefish, Atlantic needlefish, threespine stickleback, winter flounder, silver perch, American eel, rainwater killifish, tautog, oyster toadfish, cunner, Atlantic herring, bay anchovy, pollock, blueback herring and Atlantic tomcod. Only six species preferred the sand-filled bottoms: striped mullet, striped killifish, sheepshead minnow, Atlantic silverside, white mullet and northern kingfish. The remaining 17 species either showed no preference for bottom type or were encountered in such small numbers that statistical analyses of differences would not be useful. Among the common and abundant species, only four had no clear preference for a bottom type: northern puffer, tidewater silverside, bluefish and Atlantic menhaden.

FREQUENCY OF OCCURRENCE

Only the fourspine stickleback, Atlantic silverside and mummichog were found in all 155 seine hauls made over the natural bottoms (Table 4). These species usually occurred in numbers of 100 or more individuals per seine haul. Other species encountered in more than half of the seine hauls over the natural bottoms included: northern pipefish, striped killifish, threespine stickleback, American eel, Atlantic needlefish and winter flounder. Many species, such as fourspine stickleback, mummichog, northern pipefish, threespine stickleback, American eel, Atlantic needlefish, winter flounder, northern puffer,

Table 4. Frequency of Occurrence* of Species Over Natural Bottoms, 1967 and 1968 Combined

Species	Number of hauls	Hauls in which individuals of a species numbered		
		1–10	11–99	100 or more
Fourspine stickleback	155	2	8	145
Atlantic silverside	155	7	32	116
Mummichog	155	9	42	104
Northern pipefish	149	58	85	6
Striped killifish	135	84	28	3
Threespine stickleback	108	70	33	5
American eel	95	88	7	0
Atlantic needlefish	91	52	35	2
Winter flounder	90	77	13	0
Sheepshead minnow	63	41	16	6
Northern puffer	55	41	9	5
Oyster toadfish	51	47	4	0
Tautog	45	44	1	0
Silver perch	40	28	11	1
Cunner	33	30	3	0
Rainwater killifish	30	21	9	0
Bluefish	19	19	0	0
Tidewater silverside	18	17	1	0
Atlantic menhaden	11	11	0	0
Atlantic tomcod	10	10	0	0
Atlantic herring	8	5	3	0
Pollock	7	7	0	0
Northern kingfish	6	6	0	0
Striped mullet	5	5	0	0
Bay anchovy	4	3	1	0
Blueback herring	4	3	1	0
White mullet	3	1	1	1
Spotted hake	3	3	0	0
Northern sennet	3	3	0	0
Gray snapper	2	2	0	0
Permit	2	2	0	0
American sand lance	1	1	0	0
Grubby	1	1	0	0
White hake	1	1	0	0
Smooth trunkfish	1	1	0	0
Northern searobin	1	1	0	0
Windowpane	1	1	0	0
Scup	1	1	0	0

*In terms of number of seine hauls in which species occurred; total number of hauls = 155.

oyster toadfish, tautog, cunner and rainwater killifish, appeared more frequently over the natural-bottom areas than they did over the sand-filled areas (Tables 4 and 5). Silver perch, which were taken with a fair degree of regularity over the natural bottoms from August through October, were completely absent over the sand-filled bottoms. However, Alperin and Schaefer (1964) found silver perch in three of 10 seine hauls at Mercer's Island in Great South Bay. The environment

TABLE 5. FREQUENCY OF OCCURRENCE OF SPECIES OVER SAND-FILLED BOTTOMS, 1967 AND 1968 COMBINED

Species	Number of hauls	Hauls in which individuals of a species numbered		
		1–10	11–99	100 or more
Striped killifish	154	16	28	110
Atlantic silverside	147	12	18	117
Mummichog	132	47	78	17
Fourspine stickleback	119	66	33	20
Northern pipefish	93	69	24	0
Sheepshead minnow	90	34	26	30
Atlantic needlefish	72	46	25	1
Winter flounder	68	61	7	0
Northern puffer	33	17	8	8
Striped mullet	27	14	7	6
White mullet	20	5	9	6
American eel	17	17	0	0
Northern kingfish	16	9	6	1
Oyster toadfish	13	13	0	0
Bluefish	12	11	1	0
Tidewater silverside	10	8	2	0
Atlantic menhaden	8	8	0	0
Threespine stickleback	7	7	0	0
Rainwater killifish	7	7	0	0
Permit	5	5	0	0
Bay anchovy	4	4	0	0
Tautog	3	3	0	0
Atlantic herring	2	1	1	0
Cunner	2	2	0	0
Windowpane	2	2	0	0
Alewife	1	1	0	0
American sand lance	1	1	0	0
Black sea bass	1	1	0	0
Grubby	1	1	0	0

*In terms of number of seine hauls in which species occurred; total number of hauls = 155.

at Mercer's Island was not unlike that of the sand-filled areas discussed in this paper.

No species was taken in all seine hauls over sand-filled bottoms (Table 5). However, striped killifish were missing from only one haul (May 9, 1968 at Captree Island when no fish of any kind were captured). The Atlantic silverside was also frequently found over the sand-filled bottoms, being absent from only eight hauls. Usually, both the striped killifish and the Atlantic silverside were encountered in numbers of 100 or more individuals per haul. Mummichog, fourspine stickleback, northern pipefish and sheepshead minnow were all found in well over half of the seine hauls over the sand-filled bottoms. Other fish commonly found in this environment included Atlantic needlefish, winter flounder, striped mullet and white mullet. Only a few

species that were taken with any degree of regularity were found more frequently over the sand-filled bottoms than over the natural bottoms; these were striped killifish, sheepshead minnow, the mullets and (in 1967) northern kingfish.

There were some yearly differences in frequency of occurrence not shown in Tables 4 and 5. For the northern puffer, 38 of the 55 occurrences (including all those in excess of 10 individuals) over the natural bottoms, and 28 of the 33 occurrences over the sand-filled bottoms, were in 1967. For the northern kingfish, all occurrences over the sand-filled bottoms were in 1967. For the striped mullet, 16 of the 27 occurrences (including all of those of 100 or more individuals) over the sand-filled bottoms were in 1967. White mullet and tidewater silverside were found only in 1968.

Species Diversity

It has often been observed that substantial modifications of natural environments result in decreased diversity of their associated communities. A commonly used measure of community diversity was applied to see if the sand-filled bottoms had significantly less species diversity than did the natural bottoms. For each seine haul, the mean diversity was calculated as described by Margalef (1957):

$$I = \frac{1}{N} \log_2 \frac{N!}{N_1!\ N_2! \ldots N_n!}$$

where I = diversity
N_1, etc. = numbers of the several species
N = total numbers in seine haul

This particular measure of diversity is used for the reasons outlined by Pielou (1967). Figure 5 illustrates mean values of I with 95 per cent confidence limits ($\bar{I} \pm t\ S_{\bar{I}}$) in the hauls over the two bottom types for each month. Seasonal changes were more pronounced than differences between the bottom types. The diversity over the natural bottoms was consistently greater than that over the sand-filled bottoms from July through September. There were no detectable differences in diversity in May, and diversity appeared to be greater over the sand-filled bottoms in October and November.

Another index of the diversity over the two bottom types may be obtained by observing the number of species per seine haul over each environment. It appears that shore-zone areas of Great South Bay that are in their natural state support a greater variety of species of fish than do sand-filled areas. To further test this hypothesis, a "*t*" test was run on the differences between the mean number of species per seine haul at each of the study stations and that for all the sites combined.

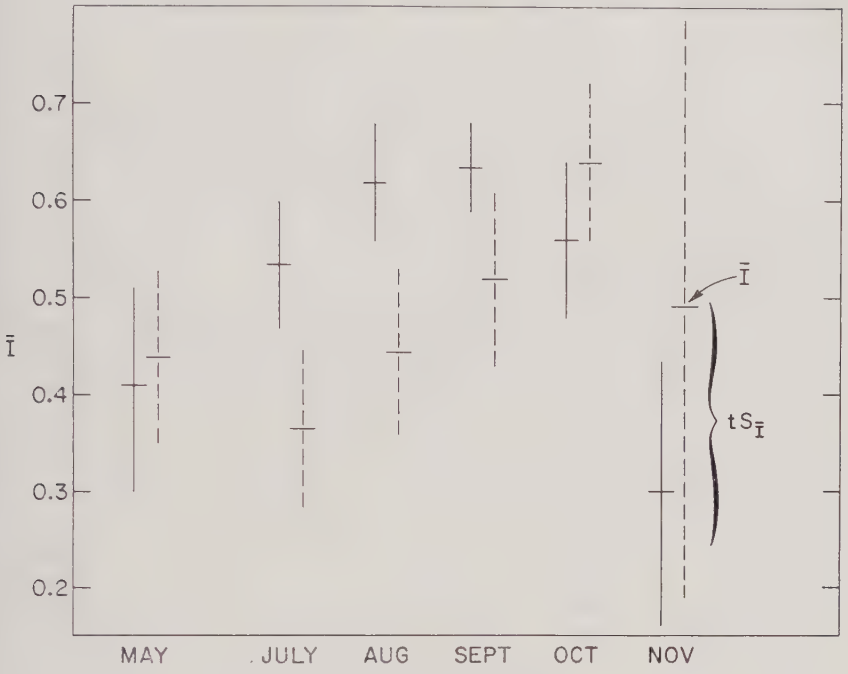

Figure 5. Means of sample species diversity by month, in terms of frequency, with 95 per cent confidence limits. Solid line denotes natural bottom; dashed line denotes sand-filled bottom.

The results (Table 6) show that the number of species per seine haul averaged significantly greater at the natural-bottom stations than at the sand-filled bottom stations. At Captree and Grass Islands, as well

Table 6. Average Number of Species Per Seine Haul Over Each Bottom Type at Each Site

Site	Natural bottom	Sand-filled bottom	Number of hauls	"t"
Captree Island	11.25	5.96	52	10.15**
Grass Island	10.00	6.94	53	7.64**
Cedar Island	8.50	7.76	50	2.11*
All sites combined	9.94	6.88	155	11.26**

*Significant at .05 level.
**Significant at .01 level.

as for all the sites combined, the differences were significant at the .01 level. At Cedar Island, the differences were significant at the .05 level.

Size Composition

Monthly and seasonal size composition for all species seined is shown in Table 7. The presence of large numbers of juveniles of a species in a particular area is often an indication of the suitability of the area as a nursery ground for the species. Although adults of many species were taken, the size ranges and the relatively small average lengths indicated that juveniles dominated the seine hauls. This emphasizes the value of the shore-zone areas of Great South Bay as a nursery ground for many species of fish.

The average length for many species appeared to differ between environments. For example, Atlantic silverside averaged smaller in size over the natural bottoms. Conversely, striped killifish averaged smaller over the sand-filled bottoms. The differences in size between environ-

Table 7. Size *Composition of Catch Over the Two Types of Bottom by Month, 1967 and 1968 Combined

Species	May				July			
	Natural		Sand-filled		Natural		Sand-filled	
	Range	Average	Range	Average	Range	Average	Range	Average
Atlantic silverside	32–139	80	34–138	83	14–139	32	14–141	40
Fourspine stickleback	25– 58	38	26– 55	40	13– 59	33	8– 52	35
Striped killifish	38–176	76	35–168	73	20–153	87	11–172	45
Mummichog	33–129	62	32–132	63	11–122	48	11–105	38
Sheepshead minnow	..	..	40– 42	41	15– 56	39	15– 60	37
Northern puffer	105–273	219	149–271	226	9–194	34	14–252	38
Northern pipefish	75–233	150	98–180	149	48–209	98	48–172	98
Atlantic needlefish	383–508	427	..	..	38–203	99	41–156	89
White mullet	..	..	..	..	..	..	25– 54	31
Striped mullet	..	..	25– 37	30	33– 58	46	22– 72	43
Threespine stickleback	16– 66	54	56– 66	61	15– 71	32	48– 60	54
Winter flounder	80–325	149	90–293	148	39 155	61	22– 89	60
Silverperch	..	..	..	..	30– 47	40	..	..
American eel	59–610	394	60–614	215	54–718	176	65–495	122
Northern kingfish	..	..	..	..	..	..	25– 90	71
Rainwater killifish	..	..	..	..	..	..	..	..
Tautog	155	155	..	..	19– 35	26	19	19
Oyster toadfish	185	185	..	..	18–204	55	..	..
Cunner	..	..	..	..	20– 35	27	22	22
Atlantic herring	28– 75	60	44– 73	53	..	..	..	..
Tidewater silverside	..	..	..	..	56– 65	60	64	64
Bluefish	..	..	..	..	55–114	83	83–107	95
Bay anchovy	63– 85	69	60– 80	67	..	..	..	..
Atlantic menhaden	37– 43	40	43	43	35	35	..	..
Pollock	42–107	72	..	..	..	..	..	..
Blueback herring	81–124	98	..	..	45– 96	71	..	..
Atlantic tomcod	..	..	..	..	100–103	102	..	..
Permit	..	..	..	..	..	..	..	..
Northern sennet	..	..	..	..	72– 94	83	..	..
American sand lance	125–127	126	37	37	..	..	..	..
Windowpane	83	83	49	49	..	..	..	..
Spotted hake	41– 48	45	..	..	..	..	..	..
Alewife	..	..	..	..	..	..	..	..
Gray snapper	..	..	..	..	38	38	..	..
Black sea bass	..	..	..	..	..	..	..	..
Smooth trunkfish	..	..	..	..	..	..	..	..
Northern searobin	..	..	..	..	..	..	..	..
Scup	..	..	..	..	..	..	..	..
White hake	59	59	..	..	..	..	..	..

*Species with forked tails, except for Atlantic needlefish, measured to fork length in millimeters; all others measured to total length in millimeters.

TABLE 7. (*continued*)

Species	August				September			
	Natural		Sand-filled		Natural		Sand-filled	
	Range	Average	Range	Average	Range	Average	Range	Average
Atlantic silverside	14–125	49	22–123	55	17–125	55	29–128	63
Fourspine stickleback	16– 57	31	18– 51	34	20– 58	33	25– 54	35
Striped killifish	19–171	84	17–162	45	30–168	82	25–173	53
Mummichog	14–135	47	18–125	50	10–124	53	18–110	52
Sheepshead minnow	10– 58	19	12– 60	34	11– 47	30	16– 60	36
Northern puffer	32–238	61	42–103	70	65–270	118	51–128	96
Northern pipefish	61–221	125	52–201	119	69–230	148	59–216	137
Atlantic needlefish	57–308	202	63–312	203	140–535	251	146–367	283
White mullet	45– 83	61	34–126	98	78–117	102	38–142	107
Striped mullet	158–171	165	29–167	81	109	109	80–226	120
Threespine stickleback	16– 51	27	24	24	26– 58	33	..	..
Winter flounder	25–106	70	40–230	84	49–313	121	46 290	92
Silver perch	17– 63	36	..	..	21–124	78	..	..
American eel	62 655	183	61–532	383	68–633	253	79–186	116
Northern kingfish	71–145	116	77–166	124	..	..	142–187	164
Rainwater killifish	17– 27	23	36	36	15– 31	23	28	28
Tautog	20– 89	54	37	37	51–118	80	28	28
Oyster toadfish	16–187	57	23– 49	37	35–250	73	45– 54	49
Cunner	20– 55	37	..	..	38–146	55	..	..
Atlantic herring	..	..	..	..	..	..	..	..
Tidewater silverside	62– 67	65	58– 63	60	62	62	..	..
Bluefish	94–162	114	120–176	152	147–195	170	163–218	184
Bay anchovy	..	..	35– 38	37	21– 36	29	..	..
Atlantic menhaden	50– 61	57	42– 49	46	40– 88	64	49–100	70
Pollock	..	..	..	..	..	..	..	..
Blueback herring	..	..	..	..	85	85	..	..
Atlantic tomcod	98–102	100	..	..	121–159	145	..	..
Permit	35	35	37– 52	42	..	..	30– 36	33
Northern sennet	103–109	106	..	..	..	..	..	..
American sand lance	..	..	..	..	..	..	..	..
Windowpane	..	..	194	194	..	..	..	..
Spotted hake	..	..	..	..	..	..	..	..
Alewife	..	..	..	..	..	..	79	79
Gray snapper	..	..	..	..	52– 60	56	..	..
Grubby	..	..	..	..	..	..	55	55
Black sea bass	..	..	..	..	..	..	41	41
Smooth trunkfish	..	..	..	..	12	12	..	..
Northern searobin	..	..	..	..	56	56	..	..
Scup	25	25	..	..	..	..	..	..
White hake	..	..	..	..	..	..	..	..

TABLE 7. (*continued*)

Species	October				November			
	Natural		Sand-filled		Natural		Sand-filled	
	Range	Average	Range	Average	Range	Average	Range	Average
Atlantic silverside	18–137	52	26–139	60	30–130	68	32–121	70
Fourspine stickleback	22– 55	34	25– 53	38	25– 52	35	25– 48	34
Striped killifish	36–150	66	27–163	57	38–153	90	38– 85	54
Mummichog	23–118	46	25–107	46	27–105	43	28– 77	41
Sheepshead minnow	18– 52	36	16– 53	36	20– 48	33	19– 51	29
Northern puffer	97–233	117	98	98	..	..	..	..
Northern pipefish	71–237	152	83–220	141	100–213	145	..	..
Atlantic needlefish	233–375	301	342–380	368	..	..	..	..
White mullet	..	..	..	..	..	..	..	..
Striped mullet	..	..	44	44	..	..	..	..
Threespine stickleback	29– 43	36	..	..	34– 45	41	35– 40	38
Winter flounder	60–270	144	53–290	120	75–223	131	91–125	105
Silver perch	18–124	79	..	..	..	..	..	..
American eel	82–381	108	91–129	110	76–134	96	..	..
Northern kingfish	..	..	..	..	..	..	..	..
Rainwater killifish	18– 34	26	24– 29	27	20– 29	26	29	29
Tautog	51–142	102	..	..	76–134	100	..	..
Oyster toadfish	37–131	62	55	55	51– 75	63	..	..
Cunner	48– 99	64	..	..	54– 94	67	77	77
Atlantic herring	..	..	..	..	..	..	..	..
Tidewater silverside	33– 65	52	37– 65	53	30– 58	38	30– 47	38
Bluefish	..	..	..	..	..	..	..	..
Bay anchovy	38	38	..	..	..	..	37	37
Atlantic menhaden	58	58	..	..	..	..	..	..
Pollock	..	..	..	..	..	..	..	..
Blueback herring	..	..	..	..	..	..	..	..
Atlantic tomcod	133–231	158	..	..	..	..	..	..
Permit	35	35	..	..	..	..	..	..
Northern sennet	..	..	..	..	..	..	..	..
American sand lance	..	..	..	..	..	..	..	..
Windowpane	..	..	..	..	..	..	..	..
Spotted hake	..	..	..	..	..	..	..	..
Alewife	..	..	..	..	..	..	..	..
Gray snapper	..	..	..	..	..	..	..	..
Grubby	..	..	..	..	..	..	..	..
Black sea bass	..	..	..	..	..	..	..	..
Smooth trunkfish	..	..	..	..	..	..	..	..
Northern searobin	..	..	..	..	..	..	..	..
Scup	..	..	..	..	..	..	..	..
White hake	..	..	..	..	..	..	..	..

TABLE 7. (*continued*)

Species	All Months			
	Natural		Sand-filled	
	Range	Average	Range	Average
Atlantic silverside	14–139	50	14–141	55
Fourspine stickleback	13– 59	34	8– 55	37
Striped killifish	17-176	82	11–173	56
Mummichog	10–135	50	11–132	48
Sheepshead minnow	10– 58	31	12– 60	35
Northern puffer	9–273	59	14–252	58
Northern pipefish	48–223	141	48–220	131
Atlantic needlefish	38 53	165	41–380	155
White mullet	45–117	70	25–142	72
Striped mullet	33–171	106	22–226	60
Threespine stickleback	15– 71	34	24– 66	48
Winter flounder	25–325	119	22–293	101
Silver perch	17–124	76	..	..
American eel	54–718	204	60–614	191
Northern kingfish	71–145	116	25–187	132
Rainwater killifish	15– 34	24	24– 36	28
Tautog	19 155	81	19– 37	28
Oyster toadfish	16–250	62	23– 55	42
Cunner	20–146	50	22– 77	50
Atlantic herring	28– 75	60	44– 73	53
Tidewater silverside	30– 67	48	30– 65	43
Bluefish	55–195	112	83–218	160
Bay anchovy	21– 85	65	35– 80	47
Atlantic menhaden	35– 88	60	42–100	64
Pollock	42–107	72	..	..
Blueback herring	45 124	95	..	..
Atlantic tomcod	98–231	140	..	..
Permit	35	35	30– 52	38
Northern sennet	72–109	95	..	..
American sand lance	125–127	126	37	37
Windowpane	83	83	49–194	122
Spotted hake	41– 48	45	..	..
Alewife	..	..	79	79
Gray snapper	52– 60	56	..	..
Grubby	38	38	55	55
Black sea bass	..	..	41	41
Smooth trunkfish	12	12	..	..
Northern searobin	56	56	..	..
Scup	25	25	..	..
Whiteshake	59	59	..	..

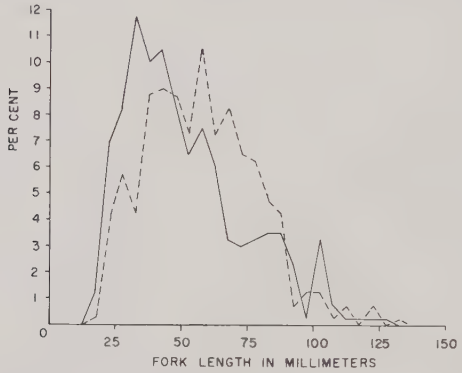

Figure 6. Length-frequency distribution of Atlantic silverside. Solid line represents random sample of 400 fish from 13,087 taken over natural bottoms. Dashed line represents random sample of 400 fish from 12,527 taken over sand-filled bottoms.

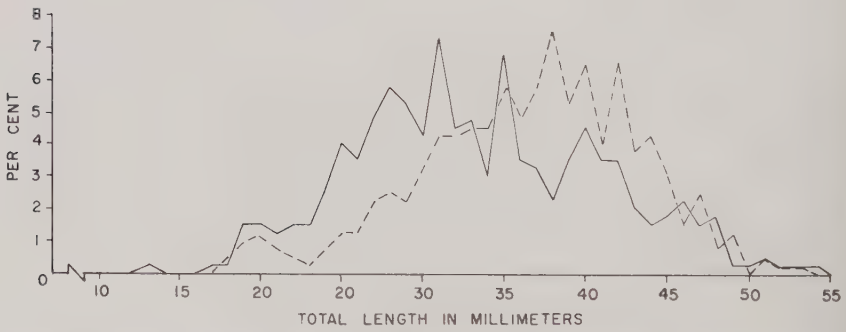

Figure 7. Length-frequency distribution of fourspine stickleback. Solid line represents random sample of 400 fish from 14,866 taken over natural bottoms. Dashed liner represents random sample of 400 fiish from 3,323 taken over sand-filled bottoms.

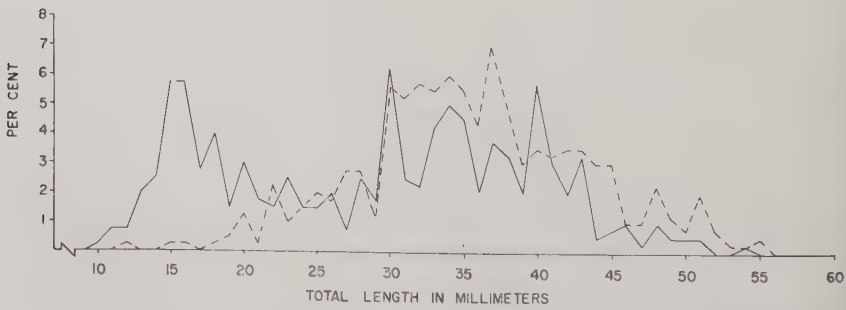

Figure 8. Length-frequency distribution of sheepshead minnow. Solid line represents random sample of 400 fish from 1,329 taken over natural bottoms. Dashed line represents random sample of 400 fish from 4,416 taken over sand-filled bottoms.

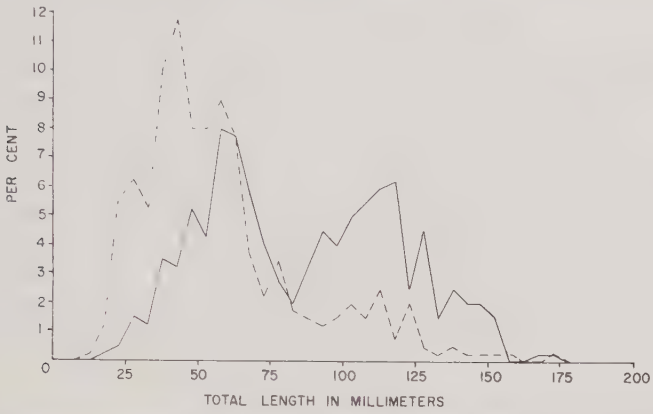

Figure 9. Length-frequency distribution of striped killifish. Solid line represents random sample of 400 fish from 1,453 taken over natural bottoms. Dashed line represents random sample of 400 fish from 12,270 taken over sand-filled bottoms.

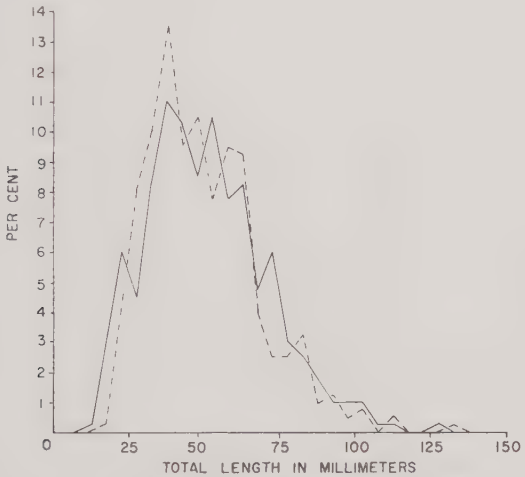

Figure 10. Length-frequency distribution of mummichog. Solid line represents random sample of 400 fish from 12,401 taken over natural bottoms. Dashed line represents random sample of 400 fish from 4,796 taken over sand-filled bottoms.

ments for many species is further shown in the graphs of length-frequency distribution for the species that were most common in both environments. Juveniles composed greater proportions of the catches of Atlantic silverside (Figure 6), fourspine stickleback (Figure 7) and sheepshead minnow (Figure 8) over the natural bottoms than over the sand-filled bottoms. On the other hand, the smallest striped killifish (Figure 9) were found in greater proportions over the sand-filled bottoms. There was little difference between environments in the size composition of the mummichog (Figure 10) taken.

Temperature and Salinity

Temperature and salinity ranges for all species captured are shown in Table 8. Salinities ranged from 23.8 to 32.2 parts per thousand in both environments. Temperatures ranged from 36° to 82° F. (2.2° to 27.8° C.) over the natural bottoms and from 36° to 85° F. (2.2° to 29.4° C.) over the sand-filled bottoms. Although temperature and salinity have been found to be factors in seasonal and spatial distribution of fishes in estuaries (Warfel and Merriman, 1944; Gunter, 1951, 1958, 1967; Reid, 1955, 1956, 1957; Springer and Woodburn, 1960; Schwartz, 1961; Tabb and Manning, 1961; Tagatz and Dudley, 1961; Pearcy and Richards, 1962; Springer and McErlean, 1962; Tabb et al., 1962; Jerome et al., 1965, 1966, 1967; Fiske et al., 1966, 1967; Mul-

Table 8. Temperature and Salinity Ranges of Species of Fish Seined Over Natural and Sand-filled Bottoms in Great South Bay, 1967 and 1968 Combined

Species	Natural bottom		Sand-filled bottom	
	Temperature range*	Salinity range§	Temperature range*	Salinity range§
Atlantic silverside	36–82 (2.2–27.8)	23.8–32.2	36–85 (2.2–29.4)	23.8–32.2
Fourspine stickleback	36–82 (2.2–27.8)	23.8–32.2	36–85 (2.2–29.4)	23.8–32.2
Striped killifish	36–79 (2.2–26.1)	23.8–32.2	36–85 (2.2–29.4)	23.8–32.2
Mummichog	36–82 (2.2–27.8)	23.8–32.2	36–85 (2.2–29.4)	23.8–32.2
Sheepshead minnow	36–82 (2.2–27.8)	24.0–31.0	36–85 (2.2–29.4)	23.8–32.2
Northern puffer	55–82 (12.8–27.8)	23.8–30.4	56–81 (12.8–27.2)	23.8–30.6
Northern pipefish	39–82 (3.9–27.8)	23.8–31.2	46–85 (7.2–29.4)	23.8–32.2
Atlantic needlefish	60–82 (15.6–27.8)	23.8–30.4	62–85 (16.7–29.4)	23.8–30.2
White mullet	62–75 (16.7–23.9)	26.8–30.4	62–85 (16.7–29.4)	24.2–30.4
Striped mullet	69–79 (20.6–26.1)	24.0–27.0	57–81 (13.9–27.2)	23.8–29.6
Threespine stickleback	39–82 (3.9–27–8)	23.8–31.2	38–78 (3.3–25.6)	25.6–26.0
Winter flounder	39–80 (3.9–26.7)	24.0–31.2	38–80 (3.3–26.7)	23.8–31.0
Silver perch	54–78 (12.2–25.6)	24.2–30.4	.. (..)	..
American eel	48–82 (8.9–27.8)	23–8.30.8	54–78 (12.2–25.6)	23.8–29.4
Northern kingfish	69–77 (20.6–25.0)	24.2–27.4	64–78 (17.8–25.6)	23.8–27.0
Rainwater killifish	48–74 (8.9–23.3)	25.4–31.0	48–77 (8.9–25.0)	23.8–31.0
Tautog	48 77 (8.9–25.0)	24.2–31.0	62–78 (16.7–25.6)	25.6–27.0
Oyster toadfish	38–78 (3.3–25.6)	24.0–30.4	62–76 (16.7–24.4)	23.8–30.2
Cunner	48–79 (8.9–25.6)	23.8–30.8	39–80 (3.9–26.7)	25.2–28.4
Atlantic herring	54–60 (12.2–15.6)	28.4–31.0	55–58 (12.8–14.4)	30.0–30.6
Tidewater silverside	38–77 (3.3–25.0)	25.4–30.8	48–73 (8.9–22.8)	26.4–31.0
Bluefish	67–78 (19.4–25.6)	24.0–28.2	67–78 (19.4–25.6)	24.0–30.2
Bay anchovy	56–70 (13.3–21.1)	26.2–30.4	48–73 (8.9–22.8)	27.6–31.0
Atlantic menhaden	50–75 (10.0–23.9)	25.4–30.6	51–78 (10.6–25.6)	24.0–30.6
Pollock	51–62 (10.6–16.7)	29.0–30.6	.. (..)	..
Blueback herring	55–74 (12.8–23.3)	24.0–30.0	.. (..)	..
Atlantic tomcod	56 76 (13.3 24.4)	24 2–30 0	.. (..)	..
Permit	60–73 (15.6–22.8)	26.4–28.2	62–74 (16.7–23.3)	24.4–27.4
Northern sennet	66–75 (18.9–23.9)	26.8–30.0	.. (..)	..
American sand lance	50 (10.0)	29.0	55 (12.8)	29.4
Windowpane	58 (14.4)	29.0	59–76 (15.0–24.4)	25.2–31.0
Spotted hake	54–58 (12.2–14.4)	29.0–31.0	.. (..)	..
Alewife	.. (..)	..	62 (16.7)	29.4
Gray snapper	66–70 (18.9–21.1)	27.0–27.8	.. (..)	..
Grubby	69 (20.6)	25.4	69 (20.6)	25.0
Black sea bass	.. (..)	..	62 (16.7)	27.4
Smooth trunkfish	62 (16.7)	30.4	.. (..)	..
Northern searobin	70 (21.1)	25.8	.. (..)	..
Scup	65 (18.3)	28.6	.. (..)	..
White hake	54 (12.2)	27.0	.. (..)	..
Total	36–82 (2.2–27.8)	23.8–32.2	36–85 (2.2–29.4)	23.8–32.2

*Temperatures in degrees Fahrenheit (degrees Centigrade in parentheses).
§Salinity in parts per thousand.

kana, 1966), these factors usually did not differ from one site to the other on any given day of seining and may be discounted as causes of differences in fish populations over adjacent natural and sand-filled bottoms in Great South Bay.

Tides

Tidal stage at the time of each haul was recorded. However, since tidal amplitude in Great South Bay is small, and since seine hauls over the adjacent natural and sand-filled bottoms at each site were completed within an hour, tidal stage was discounted as a factor in influencing differences in fish populations in this study.

DISCUSSION

In general, it appears that the deposition of dredging spoil, particularly sand, upon vegetated shore-zone areas decreases the number of fish species present. Also, for many species, it decreases their population density as well. Some species may be entirely eliminated. This appears directly related to the elimination of the natural vegetation which both provides cover for juvenile and forage fish and harbors the organisms on which they feed. The importance of vegetation in shore-zone areas that serve as nursery grounds for fish has been shown by many authors. Reid (1954) found that "The least populated zones were those in which the bottom was composed of pure sand, since here protection was lacking and food was scarce." Hutton et al. (1956) reported that the, ". . . greatest variety and numbers of animals occur in those areas where (attached) turtle grass grows." They further stated that "Dredging and filling operations on submerged banks where attached turtle grass grows abundantly are harmful . . . and destroy feeding and breeding grounds for much of the animal life." Similar findings have been reported by Springer and Woodburn (1960), Tabb et al. (1962) Woodburn (1963), de Sylva et al. (1962) and O'Gower and Wacasey (1967).

Many of the species captured during the present study are of considerable value as bait, forage, or food and game. Indiscriminate deposition of spoil, particularly sand, from dredging operations may unfavorably affect the abundance of several of these species.

The Atlantic silverside is widely used as bait for summer flounder (*Paralichthys dentatus*) and snapper (juvenile) bluefish. In addition to its use as bait, the Atlantic silverside is consumed by such food and game fish as striped bass (*Morone saxatilis*), bluefish and summer flounder (Merriman, 1941; de Sylva et al., 1962; Poole, 1964; and Schaefer, 1970). Although the Atlantic silverside preferred the sand-filled bottoms, enormous numbers of them were found over the natural bottoms, and the smallest specimens were found in greater pro-

portions over the naturally vegetated areas, indicating that natural areas may be preferred by the species as a nursery ground.

The mummichog is another important, perhaps the most important, bait used in the summer flounder fishery. This species was far more abundant over the naturally vegetated areas.

Although the northern pipefish is not used for bait, it is a valuable forage fish. Poole (1964) found the species to rank first in the occurrence of fish in the stomachs of summer flounder he examined. Striped bass also feed upon pipefish (de Sylva et al., 1962; Schaefer, 1970). This species preferred the naturally vegetated areas.

Sticklebacks of two species were extremely abundant and preferred the naturally vegetated areas. Although large numbers were occasionally found over the sand-filled bottoms, these were probably stragglers from the vegetated areas as Warfel and Merriman (1944) suggested for those found at a sand beach in Connecticut. The fourspine stickleback has been found in striped bass stomachs (Schaefer, 1970) and has been observed by the senior author from the stomachs of summer flounder that were being cleaned by anglers. In addition, the fourspine stickleback has been found to play a role in cleaning symbiosis (Tyler, 1963).

Important food and game fish such as Atlantic herring, American eel, Atlantic tomcod, pollock, tautog and winter flounder all preferred the naturally vegetated areas.

It appears that all these species would be detrimentally affected by indiscriminate spoil deposition upon the naturally vegetated shorezone areas in Great South Bay.

On the other hand, it appears that a few species might be increased in abundance by sand filling in such areas. These include striped killifish, mullets and northern kingfish.

The striped killifish, because of its size, may be of value as a forage fish and potentially as a bait fish. However, it has been observed that, when local anglers find striped killifish mixed with mummichogs purchased for bait, they almost invariably discard them. Most anglers seem to feel that the striped killifish is neither hardy enough to use for bait nor acceptable by summer flounder.

The northern kingfish is of great importance to anglers fishing the surf (Briggs, 1962, 1965) and is also taken, at times, by other anglers. All those taken in the present study appeared to be young of the year, according to the criteria of Schaefer (1965), indicating that this species prefers sandy areas without vegetation as nursery grounds.

Although the two species of mullet found in Great South Bay clearly preferred the sand-filled bottoms, in southern waters their nursery grounds are apparently grass-flat areas. For example, Tabb

(1958) stated that "Such an environment [shallow grass flats] is also preferred by black mullet, *Mugil cephalus*. . . ."

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SOME REPRODUCTIVE ANOMALIES IN FEMALE WHITE-TAILED DEER FROM NEW YORK[1]

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ABSTRACT

A total of 2,069 pregnant white-tailed deer and 3,575 associated embryos were examined. Ten instances of polyovulation were noted. Intrauterine migration of fertilized ova had occurred in 48 per cent of the specimens for which the necessary data were complete. Five instances involving twin embryos in one uterine horn and none in the other were noted. Dermoid ovarian cysts were noted in seven instances. Data on the incidence of dead embryos *in utero,* mummification and embryo emaciation were recorded. No evidence of abortion was found. Data on size differences among twin embryos of opposite sex indicated that males grew more rapidly than females and that, at term, males were longer than females in 65 per cent of the cases. Data for multiple embryos in the same uterus showed a size differential of 10 per cent or more in 7.5 per cent of such groups.

From 1960 to 1968, a total of 2,069 pregnant white-tailed deer and 3,575 associated embryos were examined as part of a statewide study of reproduction rates. Several reproductive anomalies were noted. Although these conditions may be of little management significance, the observations are of interest.

The deer examined came principally from two sources: (1) special post-season deer hunts; and (2) deer dying accidentally from various causes, chiefly automobile collisions.

During the special hunts, deer brought uneviscerated by the hunters to a checking station on the area were field dressed by Department personnel who removed the reproductive tract of each female and recorded pertinent data. The reproductive tracts were labelled and stored in 10 per cent formalin. Where arrangements could be made to examine road-killed deer and those dying from other causes, throughout the State, similar data were also recorded by Department personnel. Reproductive tracts from these deer were labelled and stored in plastic bags in commercial freeze lockers. Age of the animals was determined by the technique of Severinghaus (1949).

Each tract was later examined in the laboratory. Ovaries were sectioned with a razor blade or scalpel. Section thickness varied from 0.5 to 1.0 millimeter. For each animal, the number of corpora lutea, and of corpora albicantia for 1½-year-old deer, and their distribution between the ovaries were recorded. Uteri were examined for the pres-

[1]A contribution of Federal Aid in Fish and Wildlife Restoration Project W-89-R.

ence of embryos, and if any were present their distribution between the uterine horns was recorded. The crown-rump measurement of each embryo was taken by the technique described by Cheatum and Morton (1946). Because gross examination of the external genitalia was the sole criterion used, sex was recorded only for embryos some 65 millimeters or more in length.

POLYOVULATION

Polyovulation means that two or more ova develop in, and rupture from, a single Graafian follicle and result in the formation of just

Table 1. Occurrence of Polyovulation in White-tailed Deer in New York

Locality	Age	Number of corpora lutea		Number of embryos	
		Right ovary	Left ovary	Right horn	Left horn
Seneca Army Depot (Seneca County)	4½ years	1	1	1 male	1 male 1 female
	1½ years	1	0	1*	1*
Sullivan County	1½ years	0	1	1 male	1 female
Ripley (Chautauqua County)	7 months	1	0	1 male	1 male
	1½ years	1	1	1 male 1 female	1 female
	3½ years	1	1	1 male	2 males
	5½ years	0	1	1 female	1 male
Lordville (Delaware County)	3½ years	0	1	1*	1*
	5½ years	0	1	1 female	1 male
	7½ years	1	1	1 female	2 males

*Not sexed.

one corpus luteum. Ten instances of polyovulation were noted (Table 1), three of which have been reported (Hesselton et al., 1964); Hesselton, 1967).

INTRA-UTERINE MIGRATION OF OVA

In this phenomenon, fertilized eggs migrate completely through one oviduct and the corresponding uterine horn before becoming implanted in the opposite horn. Evidence of intra-uterine migration was derived by recording which ovary, left or right, contained the corpus luteum and which uterine horn, left or right, contained the embryo or embryos. Presence of the corpus luteum in one ovary and the embryo in the opposite uterine horn would mean that migration had

TABLE 2. FREQUENCY OF INTRA-UTERINE MIGRATION OF FERTILIZED OVA IN WHITE-TAILED DEER FROM NEW YORK

Corpora lutea		Embryos		Frequency of migration (per cent)
Distribution	Number of specimens	Distribution	Number of specimens	
One in each ovary	527	One in each uterine horn *	0	0.0
One in one ovary, none in the other	295	One in opposite uterine horn	81	27.5
Two in one ovary, none in the other	566	One in each uterine horn §	566	100.0
Two in one ovary, one in the other	39	Two in uterine horn on same side as ovary with single corpus luteum, one in the other	28	71.8
Three in one ovary, none in the other	20	Two in one uterine horn, one in the other	20	100.0
Total.....	1,447		695	48.0

*No migration assumed.

§Instances of two embryos in one uterine horn and none in the other (Table 3) were so rare they are omitted from this summary.

taken place. Table 2 summarizes the frequency of such migration for the specimens having an exact agreement between the number of corpora lutea and the number of embryos.

TABLE 3. OCCURRENCE OF TWO EMBRYOS IN ONE UTERINE HORN AND NONE IN THE OTHER

Locality	Age (years)	Number of corpora lutea		Sex and size of embryos	
		Right ovary	Left ovary	Right horn	Left horn
Lordville.....	1½	0	2	..	male —93 mm. female—92 mm.
Lordville.....	1½	0	2	60 mm.* 55 mm.*	..
Albany County.....	3½	1	1	female—240 mm.	..
St. Lawrence County	1½	0	2	female—240 mm. ..	male —94 mm. female—91 mm.
Seneca Army Depot.	3½	1	1	male —75 mm. female—70 mm.	

*Not sexed.

Twin embryos in one uterine horn and none in the other

Of the 1,234 uteri that contained more than one embryo, only five had two in one horn and none in the other. The data are summarized in Table 3. In each case the number of corpora lutea and the number of embryos were the same. Careful (albeit gross) examination of the uterus gave no evidence of an embryo or implantation site in the unoccupied horn.

Dermoid cysts

A dermoid cyst is formed by the inclusion of foreign tissue in the closure of a developmental cleft. Such cysts were found on the ovaries of seven specimens, apparently as a form of benign tumor. Grossly, they appeared as masses of a creamy white cheese-like substance with hairy fibers (also white) throughout (Figures 1 and 2). That they do not always inhibit normal functioning of the ovary was evidenced by the fact that one of the seven deer had a normal appearing corpus luteum in each ovary and a normal embryo in each uterine born despite a huge dermoid cyst in each ovary.

Twin fawns born two days apart

An adult doe, bred by a white buck as part of a genetics study at the Wildlife Research Laboratory in Delmar, gave birth to two fawns two days apart (Hesselton and Van Dyke, 1969). The first fawn, a normal colored male weighing 7¼ pounds, was born during the night of July 7, 1968. The second, a white male weighing 6 pounds, was born during the early morning of July 9.

Dead embryos *in utero*

Of the 2,069 does, 35 contained one or more dead embroys or evidence that an embryo had been present. There were 32 recognizable dead embryos among the 3,575 examined, and in 13 other instances evidence indicated an embryo had been present but had decomposed to such an extent as to be unrecognizable. Three of these deer had only one embryo. Among the 24 that had two embroys, both were dead in three cases while only one was dead in the other 21 cases. Of the eight that had three embryos, one had a single dead embryo, five had two dead embryos in the same uterine horn and two had one dead embryo in each horn. It is not known whether the single dead embryo was alone in one horn or with the live embryo in the other horn. For all the specimens examined, the frequency of dead embryos was 0.44 per cent among singletons, 1.89 per cent among twins and 6.40 per cent among triplets.

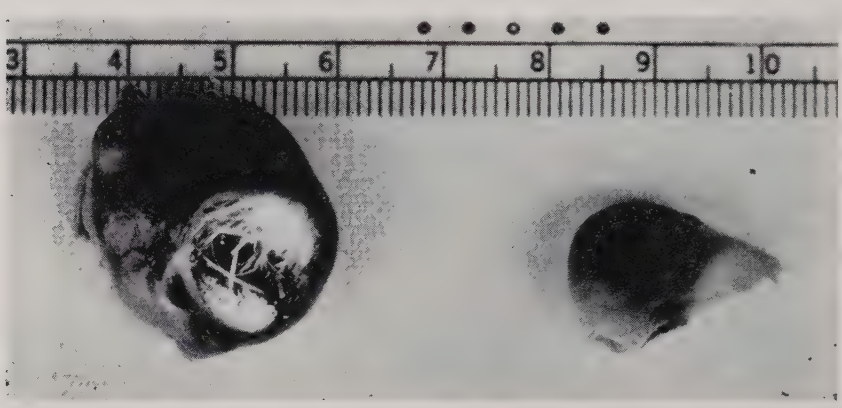

Figure 1. Ovaries of white-tailed deer: (right) normal, (left) showing dermoid cyst; the latter cut open for purposes of illustration. (scale in millimeters)

Figure 2 Ovary of white-tailed deer, cross-sectioned and opened, showing evidence of several dermoid cysts.

Decomposition of a dead embryo seems to follow one of three courses. One type, actual mummification (Figures 3 and 4), was noted on nine occasions. This phenomenon is characterized by fetal death, failure of abortion, resorption of placental fluids, dehydration of the

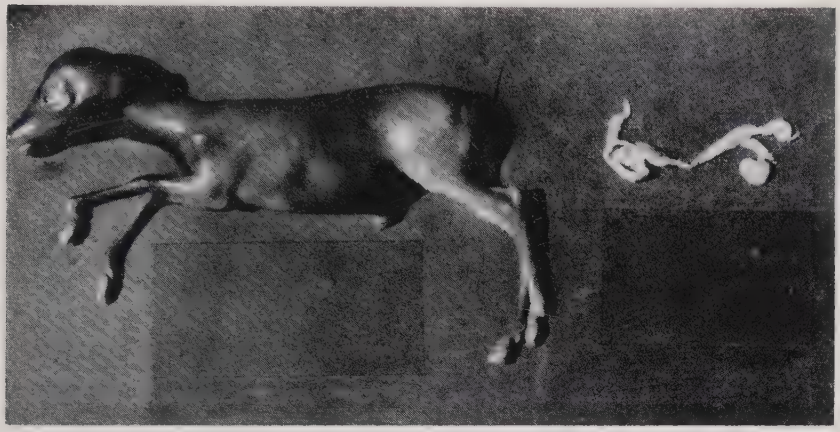

Figure 3. Twin embryos from the same female white-tailed deer killed 107 days after conception: (left) normal embryo, (right) mummified embryo that had died after 37 days. Ages estimated according to Cheatum and Morton (1946).

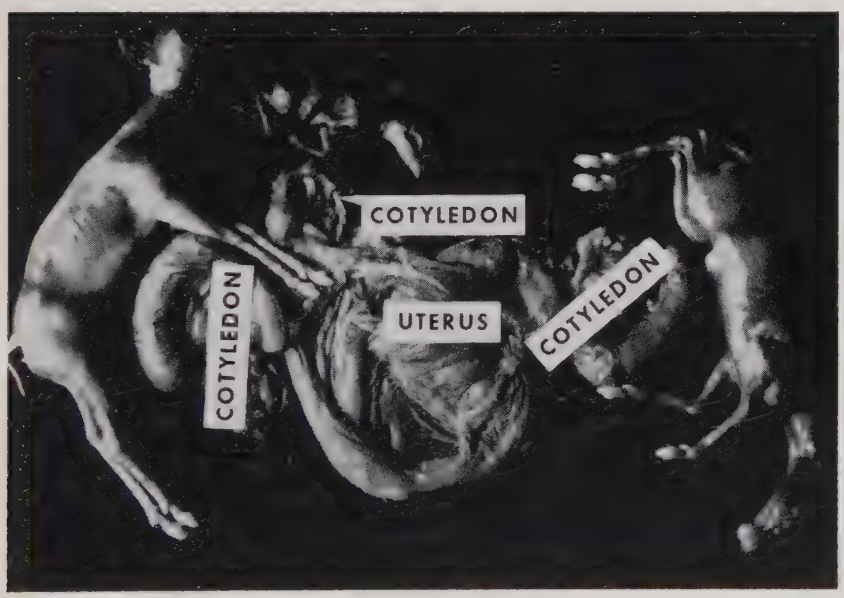

Figure 4. Reproductive tract of female white-tailed deer killed about 4½ months after conception showing two normal embryos and one mumified embryo.

fetus and its membranes, and involution of endometrium and uterus. In domestic animals, it is observed most commonly in cattle and pigs and occasionally in sheep, horses, dogs and cats as reported by Roberts (1962). It occurs apparently because bacteria do not invade the uterus,

but why this happens is not clear although current work has indicated that a genetic factor may be involved. A second type of decomposition results in the uterus being filled with whitish cheesy material, probably phagocytes that have ingested the dead, rotting embryo and associated tissues. The third type of decomposition is similar to the second, except the material is reddish in appearance. This may simply be a result of hemorrhaging because most of the deer involved died from some form of violent death, i.e., shooting or motor vehicle collision. In both the second and third types a decomposing embryo, or the remains of an embryo, was usually still evident, but occasionally evidence of an embryo, *per se,* was not apparent, probably because it had been completely ingested.

No evidence of abortion was found. In fact, the data presented here and under the following topic indicate that abortions among white-tailed deer probably do not occur.

EMACIATED LIVE EMBRYOS

Among the specimens examined, 32 obviously emaciated, but still live, embryos were found. They occurred in females that were apparently in excellent physical condition as well as in females that were suffering from poor nutrition. The females represented all stages of pregnancy, but embryos of this sort are more difficult to recognize in the small "embryo" stage than in the larger fetus stage. Since only the grossly obvious cases were recorded, others were probably present but overlooked. Also, all the reproductive tracts collected could not be used for this purpose because in a number of cases the uterus had been damaged to an extent that determination was questionable.

Considering the useable material, of 623 singleton embryos, seven, or 1.1 per cent, were emaciated but alive. For 1,234 sets of twins, there were 12 instances in which this was true of one of the embryos and four instances in which it was true of both embryos, or 0.8 per cent of the total number of embryos involved. Among 108 sets of triplets, five, or 1.5 per cent of the total embryos, exhibited this condition. In two instances, two of the three embryos were emaciated, one in each horn of the uterus in one case (distribution unknown in the other). In one instance the emaciated embryo was in the same horn with a healthy embryo. It is assumed that all of the emaciated embryos were doomed to die.

DIFFERENCES IN SIZE AMONG TWIN AND TRIPLET EMBRYOS

For all embryos the crown-rump measurement was taken by the technique described by Cheatum and Morton (1946). There were 1,321 instances in which comparable length data were available for

two or more embryos from the same female. Within such groups, a gross difference in size was arbitrarily considered to exist when the embryos differed by 10 per cent or more in length. Such differences occurred in 100, or 7.5 per cent, of the groups involved. Several of the more notable examples may be cited.

A 3-year-old female, killed by an automobile in Columbia County on June 1, 1966, was carrying two embryos—one a male that was 545 millimeters long and weighed 9 pounds, 10 ounces; and the other a female that was 500 millimeters long and weighed 6 pounds, 13 ounces. This male fawn was the largest *in utero* fawn that was measured during the study. Based on the embryo-age charts of Cheatum and Morton (1946) and Armstrong (1950) these embryos were in excess of 215 days old. These charts only go to 500 millimeters which is equal to a gestation period of 215 days. Even though these specimens did not quite meet the 10 per cent differential, they are included because of their unusual size.

A 2-year-old female, killed by an automobile in Albnay County on May 26, 1967, was carrying two embryos—one a female that was 500 millimeters long and weighed 7 pounds; and the other a male that was 410 millimeters long and weighed 5 pounds, 8 ounces.

A 4-year-old female, killed by an automobile in Allegany County on May 12, 1962, was carrying three embryos. Two males were in one uterine horn; one was 240 millimeters long and the other was 345 millimeters long. A female in the other uterine horn was 330 millimeters long. None of these embryos was weighed.

A 2-year-old female, killed by an automobile in Madison County in March 1967, was carrying two embryos—one a female that was 315 millimeters long and weighed 2 pounds, 6 ounces; and the other a male that was 275 millimeters long and weighed 1 pound, 9 ounces. In addition to the size differential, several other differences suggested this may have been a case of superfetation. Short, golden brown hairs were visible all over the crown of the female, but not on the male. Hair on the limbs was more prominent on the female than on the male. Characteristic "white" spots on the coat were distinct on the female, but indistinct on the male. The muzzle of the female had more pigment than did that of the male. Also there were vibrissae present on the cheeks of the female, but not on the male.

Relative size of the two embryos was tabulated for 635 sets of twins that comprised one of each sex. The male was longer than the female in 54 per cent of the cases, the female was longer in 27 per cent and the two were equal in 19 per cent. Further examination of the data showed that as gestation progressed the male generally grew faster. Also, as the embryos approached term, one or the other was longer in

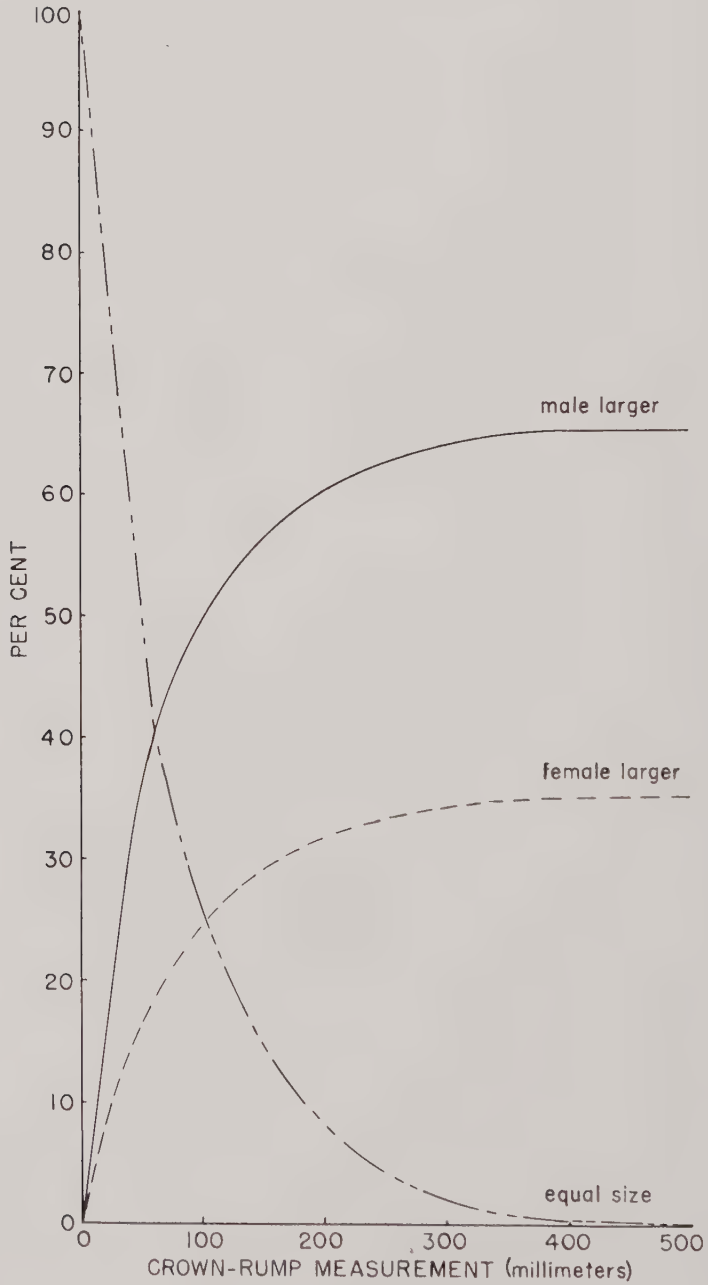

Figure 5. Relative size of male and female embryos, as gestation progressed, among 635 sets of twins comprising one of each sex, based on crown-rump measurement. Curves projected for embryos less than 65 millimeters long because specimens in this size range were not sexed.

virtually all instances. At term, the male was longer in 65 per cent of the cases. The data are illustrated in Figure 5. Embryos smaller than 65 to 70 millimeters long were not sexed because of the difficulty in distinguishing the sexes based on external genitalia only.

MONSTERS

Only two embryos were grossly misshapen. One, a singleton female 195 millimeters long, was from a 3½-year-old doe collected in Hamilton County. All four legs were extremely "bowed" out and ended in stumps at the distal end of the metatarsal and metacarpal bones. Grossly, there were not even vestigal digits. Both the mandible and premaxillary bones were misshapen to the point that the skull appeared "bird like".

The other was also from a 3½-year-old doe and was taken during one of the post-season deer hunts at Lordville in Delaware County. A female 74 millimeters long, it was one of twins. It legs were essentially the same as those of the foregoing specimen. It appeared to be normal in all other respects. Its twin was a male 73 millimeters long which appeared to be normal.

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DIGESTION RATE OF LARVAL LARGEMOUTH BASS[1]

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ABSTRACT

The relationship between digestion rate and temperature for active and non-active larval largemouth bass was examined for the range from 17° to 23° C. The ratio of active to non-active digestion was approximately 2 to 1 for all temperatures. The rates of digestion decreased linearly as temperature increased, i.e., 10.4 minutes per degree of temperature rise for active digestion and 18.1 minutes per degree of temperature rise for non-active digestion.

Digestion rates of fishes play an important role in the estimation of fish production. Daily or hourly rations can be calculated from information on digestion rates and stomach analysis. This knowledge, in combination with information on growth and metabolism, can lead to predictions of energy conversion between and within trophic levels and evaluations of biomass.

Historically there has been a great deal of literature on the digestion rates of fishes, and the largemouth bass has been no exception (Hathaway, 1927; Markus, 1932; Hunt, 1960; Molinar and Tolg, 1962). However, all of the research on largemouth bass digestion has concerned juveniles and adults rather than larvae. The purpose of the research reported here was to evaluate the effects of ambient temperatures on the digestion rates of larval largemouth bass (*Micropterus salmoides*).

MATERIALS AND METHODS

Mixed zooplankton samples consisting of *Diaptomus* sp., *Mesocyclops* sp., *Daphnia* sp., *Bosmina* sp. and *Chydorus* sp. were dyed in National Fast Blue, rinsed in pond water and placed in 10-liter aquaria. Groups of 10 to 15 actively feeding larvae were placed with the plankters and observed until dyed plankters were apparent in their stomachs. Transparency of the larve permitted visual observation of dyed plankters in stomachs of living larvae. To determine the evacuation time of the stomach and intestine under active feeding conditions, larvae containing dyed plankters were removed and placed

[1]A contribution of the New York Cooperative Fishery Unit at Cornell University, the New York State Department of Environmental Conservation and the U.S. Bureau of Sport Fisheries and Wildlife cooperating. Thanks are expressed to Drs. Clarence A. Carlson, LaMont C. Cole and Daniel Q. Thompson for their critical review of the manuscript.

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in other aquaria with similar concentrations of non-dyed plankton, and the times for the dyed plankters to pass from individual larvae were recorded. Evacuation times for nonfeeding larvae were determined by placing larvae containing dyed plankters in aquaria devoid of food and recording the times required for passage.

Temperatures during the experiments were ambient and ranged from 17° to 23° C. Since temperature fluctuated during a single experiment, temperatures at the beginning and end were recorded, and the mean was considered the experimental temperature. All larvae did not feed on dyed plankton and, as a result, variable numbers of larvae were actually tested at a given temperature. Experimental larvae ranged from 196 to 721 micrograms in mean dry weight and had been actively swimming from 2 to 8 days.

RESULTS

The ratio of digestion time for larvae not actively feeding to that for actively feeding larvae was approximately 2 to 1 at all experimental temperatures (Table 1). Regression relationships of temperature and the digestion times of actively feeding and non-actively feeding larvae were linear, and the slopes of the lines were negative (Figures 1 and 2). There was, therefore, a reduction in digestion time as

TABLE 1. DIGESTION OF ACTIVELY FEEDING AND NON-ACTIVELY FEEDING LARVAE

Temperature in degrees C.		Number of larvae tested	Mean digestion time (minutes)
Range	Mean		
	Active		
17–19	18	26	166.2
18–20	19	21	148.3
..	20	20	164.0
..	21	23	130.2
22–23	22.5	33	118.5
	Non-active		
17–19	18	8	309.4
18–20	19	8	285.6
..	20	10	309.0
20–21	20.5	20	245.3
..	21	10	259.0
22–23	22.5	12	229.2

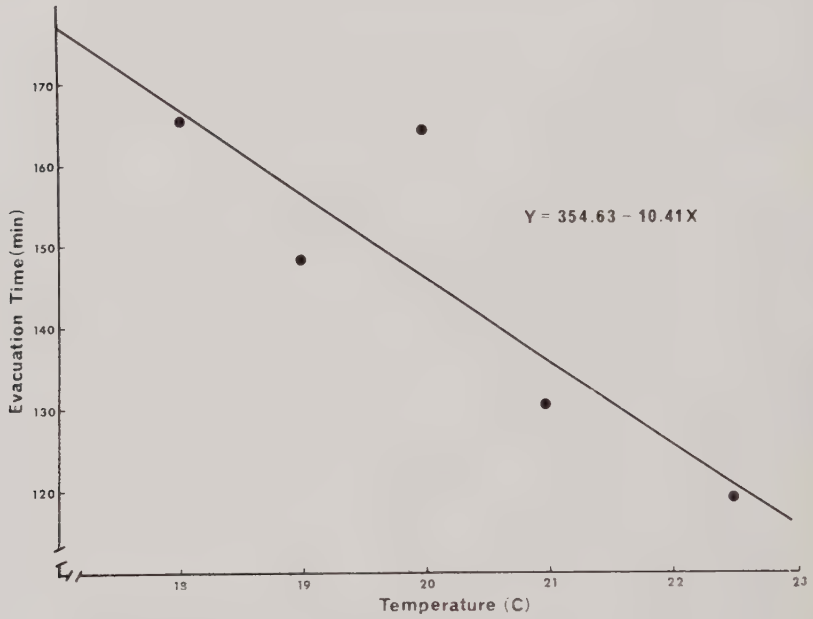

Figure 1. Relationship between evacuation time and temperature for actively feeding bass larvae.

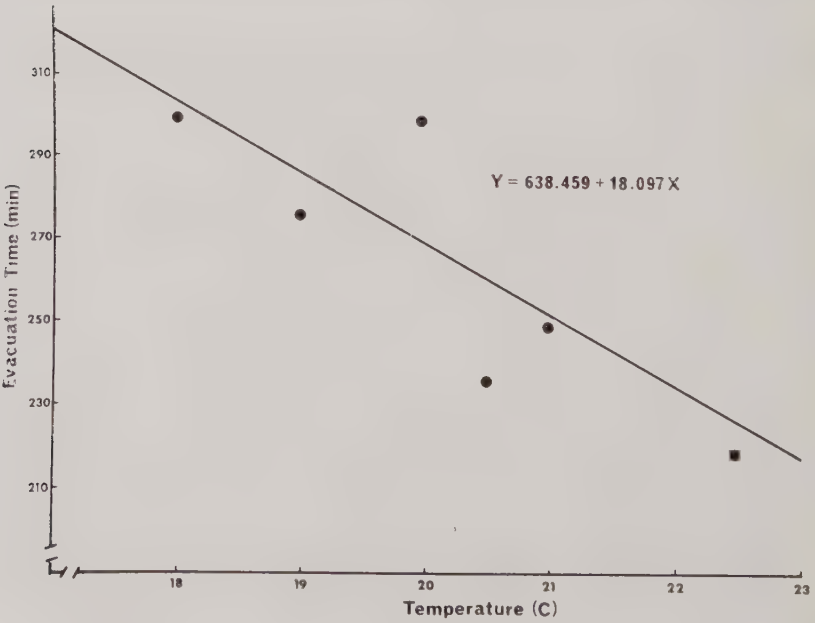

Figure 2. Relationship between evacuation time and temperature for non-actively feeding bass larvae.

temperature increased. The rate of digestion (slope of regression line) decreased 10.4 minutes per degree of temperature rise for active digestion and 18.1 minutes per degree of temperature rise for non-active digestion.

DISCUSSION

The short evacuation times noted in these experiments are comparable to results of work with larvae of other fish species. Chiba (1961) reported evacuation times of 1 to 8 hours for larval carp (*Cyprinus carpio*) at temperatures of 18° to 29° C.

Comparisons between these results and the data of Molinar and Tolg (1962) on the digestion rates of adult largemouth bass are apt to be tenuous. Adult bass are sporadic feeders and usually have intervals between feedings to digest food. The larvae used in the present study were continuous feeders.

As was expected, digestion rates of larval bass were much higher than those of adult bass at a given temperature. The ratio of digestion time for adults to that for actively feeding larvae was approximately 10 to 1, whereas the ratio between adults and non-actively feeding larvae was 6 to 1. The digestion rate of non-actively feeding larvae is probably most comparable to that of adults, since it is assumed that adults do not feed while digesting. Panadian (1967) noted a relationship between size and digestion rate in *Megalops cyprinoides* and *Ophiocephalus striatus*. He attributed faster digestion among smaller fish to higher feeding rates, while the less frequent feeding of larger fish caused slower digestion.

Efforts to determine digestion rates for larvae in darkness showed the rates to be extremely low. Larvae with dyed plankton in their stomachs, and in the presence of non-dyed food, had not evacuated the dyed plankters after 8 hours at 20° C. Larvae were inactive in darkness and settled to the bottom of the aquarium. Consequently, it was assumed that bass larvae probably do not feed at night. Quasim (1955) reported the same type of response for the marine larvae of *Blennius pholis* and *Centronotus gunnelus*. Davis (1966), in bioenergetic studies of goldfish, observed decreasing heat production at night. Decreasing heat production and, thus, metabolism would preclude the need to feed.

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GENERAL NOTES

AERIAL PHOTOGRAPHS AS AN AID IN BEAVER MANAGEMENT

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In most investigations concerned with population levels of beaver (*Castor canadensis*), findings are expressed in terms of active colonies per stream mile or per unit of area. Although this provides data on current abundance, it does not necessarily provide information on population levels in relation to range potential. Tremendous variations in beaver range potential exist because of topography, stream gradient, stream flow, land use and other physical factors. Therefore, efforts were made to find more meaningful ways to express beaver population levels. One approach involves the recognition of potential colony sites, and the use of aerial photographs for this purpose is discussed in this paper. Also, suggestions are made for the use of such photographs with respect to other aspects of beaver management including relations with other species of wildlife.

Techniques have been developed, but they are subject to considerable refinement. Many questions remain to be answered, and a number of suppositions need critical review. Nevertheless, the results are promising, and the methods are discussed with the thought that they may be of interest to others concerned with beaver management.

The technique of recognizing potential sites is most applicable to drainages where beaver have been resident for a number of years at fairly high population levels. In New York, it has been used for about three years, with considerable satisfaction, in areas in the northeastern part of the State. The area discussed here is situated in the spruce-balsam fir-northern hardwoods forest of the central Adirondacks where beaver have been resident since their reestablishment in the early 1900's. Vertical aerial photographs having a scale of 4 inches to a mile were used, and a pocket stereoscope was employed to aid in interpretation.

The presence of alder or marsh-type vegetation, the existence of standing water and apparent old beaver dams serve to identify the types of potential sites commonly referred to as flowages or beaver meadows. Although all potential sites certainly cannot be recognized from the photographs, it is felt that a high enough percentage can be identified to provide a good index of suitability for beaver habitation. The longer beaver have occupied a given range the more reliable the indices will be. The procedure amounts to enlisting the beaver themselves to point out suitable sites rather than being confronted with a large number of variables and relying on personal judgment. Factors such as stream gradient, other aspects of topography, water flow at different seasons of the year and to some extent food conditions for beaver are automatically taken into consideration. Evidence of past beaver occupation would indicate that the site was physically suitable for beaver habitation.

In recognizing such sites, some guidelines necessarily have to be adopted. It was felt that, in analyzing a drainage, one should proceed upstream and that some consideration should be given to the tolerance of one beaver colony to another. In this study, when a series of flowages occurred within a relatively small area, a dam site, in order to qualify as an individual potential site, had to be at least ¼ mile (in a straight line) upstream from the anticipated summer flowline of the nearest recognized colony site downstream. Figure 1 shows 10 separate flowages which, according to this criterion, represent four potential beaver colony sites (flowages A, C, G, and J). The meadow-like areas, the existence of some standing water and the location of beaver dams are all quite apparent in this photograph. Stereoscopic examination makes these features even more evident.

Slow-moving deadwater streams and rivers characterized by relatively steep banks and deep channels, where recognition of individual sites is virtually impossible, were treated in a different manner. Potential sites were designated at points ½ mile apart (in a straight line) on deadwaters appearing to constitute suitable beaver habitat. Figure 2 depicts a section of deadwater river that illustrates this category.

For purposes of standardization, each permanent pond or lake, regardless of size, was considered to represent one potential beaver colony site.

Figure 1. Aerial photograph of a section of the central Adirondacks near Speculator showing individual beaver flowages A to J. According to guidelines outlined in the text, flowages A, C, G and J would be considered separate potential beaver colony sites. All the flowages represent potential beaver-waterfowl habitat. At the time of the photograph, flowage C was probably inhabited by a colony of beaver; the dark color indicates a fairly high level of water. Flowage G had probably contained beaver within the previous year or so. The other flowages appear to have been dead for some time. Log roads can be noted throughout the area. Three of the more obvious log landings, which at times can be confused with small beaver flowages, are designated "L." (Photo courtesy American Air Surveys, Inc., Pittsburgh, Pa.)

Thus, three distinct potential site categories were considered. What this sort of information may reveal is illustrated by a recent evaluation of 46 square miles in the central Adirondacks. A total of 66 sites were recognized, of which 47 were flowages of the marsh or alder type, 13 were situated on deadwaters and six were on lakes or ponds.

It is important that standardized procedures be developed and that the criteria used be based on all available knowledge. The tolerance of one beaver colony for another needs to be more adequately resolved. Undoubtedly a number of variables such as topography and food conditions are involved. Possibly the intervals of ¼ mile for beaver flowages and ½ mile for deadwaters are not the best. Tolerance factors also enter in when considering lakes and ponds. Some lakes and ponds are capable of supporting more than one colony of beaver, while others are not capable of supporting any beaver. Some of the larger ones that experience heavy wave

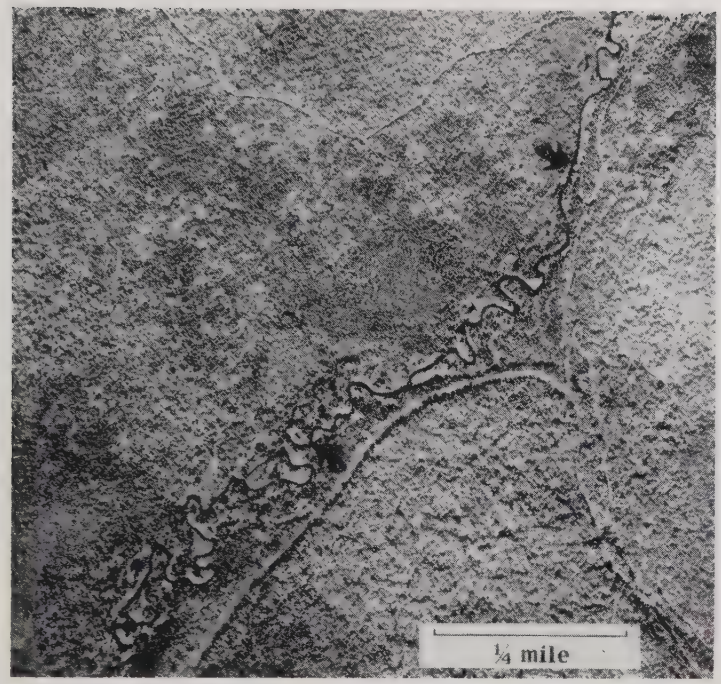

Figure 2. Aerial photograph of a section of the central Adirondacks near Speculator crossed by a slow-moving deadwater stream. This particular section of stream was considered to afford two potential beaver colony sites, but it is evident that it would seldom be possible to recognize either past or present beaver occupation. (Photo courtesy American Air Surveys, Inc., Pittsburgh, Pa.)

action or extreme fluctuations in water level, or that are basically rockbound, may not be attractive to beaver.

Although the method outlined is most applicable to drainages which beaver have occupied over a relatively long period of time at fairly high population levels, aerial photographs have been used with considerable success in other areas. But personal judgment must often be substituted for evidence of beaver activities, and greater reliance must be placed on ground surveys.

Even though a drainage has a long history of beaver habitation, a general on-the-ground knowledge of the country under consideration is essential. This is true in any technique involving aerial photograph interpretation. Spot checks should be made until confidence in interpretation is gained.

Once the potential colony sites in an area have been recognized, a meaningful basis will exist for expressing the relationship of beaver occupancy to the available habitat. Where the same criteria for interpretation have been used, conditions in different drainages may be compared.

To obtain some measure of the attractiveness and potential of a site with respect to food conditions, the percentage of the available crown area comprised of hardwood tree species within 300 feet of the edge of each flowage (a figure generally accepted in beaver studies) can be estimated. Individual flowages can then be rated from the aerial photographs on the basis of forest composition and another index of beaver potential developed.

Since beaver flowages often provide waterfowl habitat, information on wetland acreage of the beaver-meadow type that may be suitable for waterfowl can be quickly calculated by using a dot-grid overlay. A 64-dot-per-square-inch grid has been found to be very satisfactory for calculating flowage area to the nearest whole

View of flowage C (see Figure 1) after it was no longer occupied by beaver.

Typical section of the deadwater stream shown in Figure 2.

acre. The 10 flowages designated in Figure 1 represent a total of 80 acres of potential beaver-waterfowl habitat.

Aerial photographs can also be employed to provide a fairly good picture of which of the beaver-meadow-type sites were occupied at the time the photographs were taken. The amount of the upstream edge of the dam actually functioning in backing up water and the over-all level of water in the flowage itself are indicative.

This is readily evident from Figure 1. Flowage C exhibits an obviously inundated condition and a very functional dam. Flowage G contains some water, but it is mainly confined to the channels and the dam does not appear to be well maintained. The status of the other eight flowages in respect to present or very recent beaver occupation is obvious. The limited amount of water present is confined to the original stream channels and the dams are obviously non-functional. But limitations exist, and there will always be some flowages that are questionable.

In a number of instances, sets of aerial photographs taken approximately 10 years apart were compared to assess trends in beaver pouplations. Aerial photographs from past years can afford a means of reconstructing the history of beaver populations in a given area. Photographs taken over a period of time can also be used to assess the quantity and quality of timber that beaver may be flooding. Both average annual losses of timber and projected possible losses can be calculated.

At times there are problems in determining from an aerial photograph whether a body of water is a small, permanent pond or an occupied beaver flowage. A determination can often be made if two sets of aerial photographs, taken several years apart, are available. If the water in question is a beaver flowage, one set may show it full of water and the other in a dry state.

In any case, the use of aerial photographs is proposed not as a census technique but for its value for assessing the degree of current occupation and for detecting population trends. With respect to beaver management, the information can then be correlated with the management objectives for a given area in relation to such factors as the most appropriate time and type of open season, trapping pressure, effectiveness of trappers, food conditions and existing or potential beaver damage problems.

MORBIDITY AND MORTALITY OF BIRDS DUE TO AVIAN MALARIA[1]

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From July 30 to October 10 in 1970, eight passerine birds were submitted to the Wildlife Research Laboratory at Delmar for examination or autopsy. Seven of them suffered morbidity or mortality from avian malaria, while one robin had died from mechanical damage to the head.

The first cases (July 30) were two robins (*Turdus migratorius*) and an English sparrow (*Passer domesticus*) found dead on lawns and submitted by the Rensselaer County Health Department because of suspected pesticide poisoning. The robins were both females, one adult and one juvenile. At autopsy, they were in good flesh but had pallid breast muscles, yellow-gray livers, splenomegaly, and petechiae on the surface of their hearts and brains. Heart blood and organ smears were made, fixed in absolute methyl alcohol and stained with Giemsa stain. The blood smear from the juvenile robin showed a 74 per cent parasitemia of a species of *Plasmodium* matching the key characteristics of *P. cathemerium* (Russell et al., 1963). The brain smear revealed numerous exoerythrocytic stages in the endothelial cells of the brain capillaries. The blood smear from the adult robin showed a 63 per cent parasitemia with what appeared to be the same species of malaria, and numerous exoerythrocytic stages in the endothelial cells of the brain capillaries were evident in the brain smear. In addition, the adult showed a few *Leucocytozoon* and microfilariae in the heart blood. The English sparrow was an immature male with similar gross pathology to the robins. A parasitemia of 46 per cent with *P. cathemerium* was found in the heart blood, but no exoerythrocytic stages were observed in the brain or other tissues.

On August 10, an adult female purple grackle (*Quiscalus quiscula*) was found dead on a lawn in Albany County. At autopsy, it showed pallid breast muscles and intestines, splenomegaly, and petechiae in the brain. A 36 per cent parasitemia with a species of *Plasmodium* morphologically like *P. cathemerium* was found in the heart blood, and numerous exoerythrocytic stages were found in the endothelial cells of the brain capillaries.

On August 18, a juvenile male robin was submitted after being found dead on a lawn in Dutchess County. This robin had splenomegaly, but a blood smear was useless because the bird had been partly frozen before submission and the red blood cells lysed. However, numerous malarial exoerythrocytic stages were detected in the endothelial cells of the brain capillaries and much malarial pigment was found in the liver and spleen smears.

A juvenile female robin from Albany County was submitted in a moribund condition on August 24 after it was found on a lawn and unable to stand or hold up its head. On examination of the still live robin, it was noticed that the breast muscles were very pale and that the skin had a strong yellow tinge. Microhematocrits and a blood smear were taken from blood drawn from the tarsal-metatarsal vein. The blood smear contained a 58 per cent parasitemia with a species of *Plasmodium* morphologically like *P. cathemerium* and a few others morphologically like *P. vaughani* (Russell et al., 1963). Also, 85 per cent of the red blood cells showed polychromasia, and the microhematocrits were 5 per cent. The mean hematocrit for juvenile robins is 37.3 per cent and the range is 35-40.1 per cent

[1] A contribution of Federal Aid in Fish and Wildlife Restoration Project W-35-R. The authors are grateful for the cooperation of Joseph Steeley, conservation biologist, New York State Department of Environmental Conservation, and William Glass, sanitarian, Rensselaer County Health Department.

(Petrak, 1969). The 5 per cent hematocrit and large percentage of polychromatic red blood cells are an indication of the extreme anemia brought about by the malaria. Pigeons infected with *P. pinottii* malaria do not exhibit such a marked drop in microhematocrit. The microhematocrit of pigeons at death with *P. pinottii* infections ranges from 20 to 48 per cent, with a mean of 33.2 ± 1.6; the normal microhematocrit level of adult pigeons was 52.5 ± 1.0 (Manwell and Stone, 1966).

On October 10, a female crow (*Corvus brachyrhynchos*), found unable to fly in a field in Albany County, was brought to the Laboratory and died shortly after arrival. At autopsy, it was found to be in good flesh, but its breast muscles were pale and the feathers about the vent were soiled with greenish feces. The intestines were pale, extravasations were present in the liver and there was slight splenomegaly. A heart blood smear showed a parasitemia of 28 per cent with a malaria parasite morphologically like *P. cathemerium*. The red blood cells in the heart blood exhibited 58 per cent polychromasia.

No other causes of disease were found in these birds with malaria. Herman (1969) pointed out that little is known of the effect of blood protozoa on bird hosts and populations. This is, in part, because most studies of avian malaria have been laboratory studies orientated to understanding the biology of the blood parasites. In the cases presented here, the primary cause of death appears to have been avian malaria; studies are needed to document its importance to our bird populations.

At present, the finding of sick or dead songbirds is often blamed on pesticides, and, in some cases, they can be incriminated. However, songbirds, weakened by avian malaria, and especially with neurological symptoms caused by exoerythrocytic stages, may appear to be poisoned. It is important that such birds be autopsied and studied so that the cause of the mortality can be properly ascertained.

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HEMAGGLUTINATION-INHIBITION ANTIBODY TITERS AGAINST NEWCASTLE DISEASE VIRUS IN CANADA GEESE[1]

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Newcastle disease virus is the causative agent of an infectious and often lethal disease of domestic fowl and many species of wild birds. The list of susceptible wild bird species is growing, and continued investigations of a number of domestic and wild mammals (Biester and Schwarte, 1965, pp. 647-648) reveal susceptibility.

Information regarding evidence of infection by this virus in Canada geese (*Branta canadensis*) is scanty. Page (1958) found that about 60 per cent of the Canada geese on one refuge in Illinois had virus neutralization titers higher than those for normal non-exposed chickens, but geese exposed to the virus were asymptomatic. Asplin (1947) found some geese in England (species unreported) to be temporary subclinical carriers and potential disseminators of the virus. Raszewska (1966) reported two field cases of death in 1- to 2-week-old goslings (species unreported) from the disease and, with the virus strain isolated from these cases, was able to infect 2-day-old goslings.

Canada geese captured by Conservation Department personnel annually for banding in a number of areas of the State during July have afforded an opportunity to collect blood samples for investigation. Serum samples for the present study were obtained from geese on two of these areas: the Oak Orchard Wildlife Management Area in central New York and the Wilson Hill Wildlife Management Area in northwestern New York. Blood was collected from the leg vein, the serum was removed and the samples were frozen at −40° C. prior to shipment in dry ice for testing. The hemagglutination-inhibition test was performed by standard methods[2] using the Texas GB strain of Newcastle disease virus and goose erythrocytes. In domestic fowl, titers of 1:20 or greater indicate prior exposure to the virus and are considered as positive in this report.

Table 1 gives the results of the test for 358 sera from the two areas of New York. Geese from the Wilson Hill area were tested in both 1967 and 1969, while geese from Oak Orchard were tested only in 1967. Three age groups were discernible: juvenile, yearling and adult. Three per cent of the sera from juvenile birds from Wilson Hill in 1967 had titers of 1:20 or greater; no sera from juvenile birds from Oak Orchard in 1967 or from Wilson Hill in 1969 were positive. Over 50 per cent of the yearlings from both areas in 1967 had positive sera, while none from the eight yearlings from Wilson Hill tested in 1969 was positive. Seventy per cent of the sera from adult birds from both areas in 1967 were positive, while only 20 per cent of those from Wilson Hill in 1969 were positive.

The comparable percentages of serologically positive geese in each age group, and especially in the yearling and adult birds in 1967 from both areas tested (about 170 miles apart), are of particular interest. This, coupled with the reduced incidence of positive birds in the yearlings and adults from Wilson Hill in 1969, suggests a decreased incidence of virus exposure. Except for six of 179 birds from Wilson Hill in 1967, all juveniles were negative. In comparison, in 1967 over 50 per cent of the yearlings and 70 per cent of the adults had significant titers.

It remains to be determined at what point the juvenile birds have the greatest contact with Newcastle disease virus. The difference in antibody titers between the juvenile and yearling age groups in 1967 but not in 1969 suggests that the virus contact to goslings occurs infrequently in May and June in the areas of New York studied. Serological testing in September would determine if a large number of juvenile birds become exposed to this virus on the breeding grounds prior to the fall migration. One would suspect, however, that, if this were the case, a greater percentage of these birds would become reactors by July. Nevertheless, these results indicate that Canada geese resident in New York during the summer months have been in contact with Newcastle disease virus and that they may play a role in dissemination of the virus.

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[1] A contribution of Federal Aid in Fish and Wildlife Restoration Project W-35-R. The study was carried on jointly by the New York State Departments of Health and Conservation.

[2] Appreciation is extended to the Department of Veterinary Science, University of Wisconsin, Madison, for kindly performing the test.

Table 1. Frequency of Different Levels of Hemagglutination-Inhibition Antibody Titer Against Newcastle Disease Virus in Canada Geese Sera from the Wilson Hill and Oak Orchard Wildlife Management Areas in New York, July 1967 and 1969

Titer*	Age group								
	Juvenile			Yearling			Adult		
	Wilson Hill		Oak Orchard	Wilson Hill		Oak Orchard	Wilson Hill		Oak Orchard
	1967	1969	1967	1967	1969	1967	1967	1969	1967
0	150	21	10	4	3	0	5	18	2
5	13	0	0	3	1	2	1	9	3
10	10	2	0	2	4	1	1	12	6
20	3	0	0	5	0	3	6	5	12
40	2	0	0	5	0	0	6	4	6
80	1	0	0	2	0	0	2	2	7
160	0	0	0	0	0	0	2	0	1
>320	0	0	0	0	0	0	1	0	0
Total sera tested	179	23	10	21	8	6	24	50	37
Percentage 1:20 or greater	3.4	0	0	57.1	0	50.0	70.8	20.0	70.3

*Hemagglutination-inhibitor titer expressed as reciprocal of the end-point dilution.

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INCIDENCE OF MAXILLARY CANINE TEETH IN WHITE-TAILED DEER FROM NEW YORK[1]

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The genus *Obocoileus* (i.e., white-tailed deer) has a normal tooth formula of I $\frac{0}{3}$, C $\frac{0}{1}$, PM $\frac{3}{3}$, M $\frac{3}{3}$, and the mandibular canine is modified to resemble and function as an incisor. Maxillary canine teeth are an anomaly that occurs occasionally. Nordquist (1941) found such teeth in two (0.05 per cent) of approximately 4,000 deer heads examined in California. Southwick (1954) reported a fawn with this anomaly as the first known instance in Wisconsin although some 10,000 deer had been examined for maxillary canines from 1950 to 1953. Ryel found these teeth in seven (1.9 per cent) of 360 skulls from Michigan, and he quoted Loveless and Harlow (1959) as finding them in four (4.2 per cent) of 93 skulls from Florida. Lueth (1969) reported their occurrence in deer in Alabama. Van Gelder and Hoffmeister (1953) examined white-tailed deer skulls in the collections of several museums and found maxillary canines in 11 (3.4 per cent) of 325 specimens. They also quoted R. M. Kellogg as having recorded only one or two cases in some 900 skulls. In New York, C. W. Severinghaus (personal communication) reported at least 23 cases (1.02 per cent) among some 18,000 deer examined, as well as seven instances (0.31 per cent) among 1,729 heads sent to taxidermists.

Skull of white-tailed deer showing maxillary canine teeth.

[1]A contribution of Federal Aid in Fish and Wildlife Restoration Project W-89-R.

Table 1. Occurrence of Maxillary Canine Teeth in White-tailed Deer in New York

Age	Male		Female		Total	
	Number	Number with canines	Number	Number with canines	Number	Number with canines
5 months or less	1	..	5	..	6	..
5½–11 months	19	..	15	1	34	1
17 months–2 years	49	3	21	1	70	4
2½ years	99	6	17	1	116	7
3½ years	109	3	13	1	122	4
4½ years	23	..	9	..	32	..
5½ years	9	1	1	..	10	1
6½ years	10	..	3	..	13	..
7½ years	5	1	5	1	10	2
8½–9½ years	2	..	2	..	4	..
Unknown	3	..	2	..	5	..
Total	329	14	93	5	422	19
Percentage with canines	xxx	4.3	xxx	5.4	xxx	4.5

One reason for the differences in incidence among these reports may be that small or unerupted maxillary canines may not be visible and are thus often overlooked. To provide more representative data, a sample of deer skulls from New York was examined specifically for this purpose. It comprised deer brought to the Wildlife Research Laboratory at Delmar (killed in highway accidents, by dogs, starvation etc.) during the fall and winter from January 1969 to March 1970, as well as deer taken during a special open season in Suffolk County and heads received by a local taxidermist. Each skull was examined by inspecting the maxilla and by scraping over the bone with a knife if no canine was immediately visible. Sex and age, and locality when known, were recorded for each specimen. Age was determined by the method of Severinghaus (1949). For convenience, the specimens, except those under 2 years old, were assigned to fall age groups. All skulls having maxillary canine teeth were cleaned and saved.

Skulls from 422 deer were examined, 329 males and 93 females. Antlered heads sent to the taxidermist for mounting accounted for the large proportion of males. The data are summarized in Table 1. Nineteen skulls (4.5 per cent) had one or two maxillary canine teeth. While many of these were evident on general inspection, a large proportion would have been overlooked in a less careful examination.

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RESULTS OF STOCKING LARGEMOUTH BASS IN NASSAU LAKE

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Nassau Lake, a 153-acre warm-water impoundment with a maximum depth of 11 feet, was formed by a 9-foot dam across the Valatie Kill in Rensselaer County (N.Y.). The lake is inhabited by largemouth bass, chain pickerel, and numerous panfish species of which white and yellow perch are the most abundant. Heavy blooms of algae are common, and an extensive fish kill during the late summer of 1962 may have resulted from rapidly decomposing algae.

For a number of years the Rensselaer County Conservation Alliance has reared largemouth bass in a 5-acre pond for stocking as fall yearlings in various lakes in the county.[1] Nassau Lake was stocked with 400 in 1960 and 5,073 in 1962. These fish ranged from 5.0 to 10.5 inches long, with an average length of 6.0 inches. Of the bass stocked, 200 in 1960 and 492 in 1962 were marked with jaw tags. Only one tag from each year's stocking was returned. Because of this apparently poor contribution to angling, it was decided to monitor the survival of bass stocked in in the lake during 1966.

During the fall of 1966, 1,350 largemouth bass averaging 7.5 inches in length were marked by removing the left ventral fin and stocked in Nassau Lake. These were fish of the 1965 year class. Fish collections were made around the entire periphery of the lake with a boat shocker (230-volt D.C.) during May 1967, October 1968 and June 1969. Largemouth bass collected were measured and examined for marks, and scale samples were taken.

Table 1 summarizes the collections made in 1967, 1968 and 1969 in Nassau Lake. Of all 1965-year-class bass collected, marked fish amounted to 41.7 per cent in 1967, 35.7 per cent in 1968 and 17.6 per cent in 1969. The variability of the appar-

TABLE 1. SUMMARY OF MARKED LARGEMOUTH BASS COLLECTED IN NASSAU LAKE IN 1967, 1968 AND 1969 IN RELATION TO NATIVE BASS COLLECTED

Year class	1967 (May)			1968 (October)			1969 (June)		
	Number	Length (inches)		Number	Length (inches)		Number	Length (inches)	
		Range	Average		Range	Average		Range	Average
Marked									
1965	15	7.2–8.3	7.5	5	9.3–11.9	10.9	3	11.6–15.6	13.2
Native									
1969	..	..	..	..	..	..	1	3.4	3.4
1968	..	..	..	7	4.4–5.9	5.3	13	3.9–6.8	6.0
1967	..	..	..	15	6.9–9.1	8.1	15	6.8–10.9	9.0
1966	1	7.5	7.5	5	7.1–12.2	9.8	7	10.0–12.5	11.9
1965	21	7.1–11.9	9.0	9	11.6–15.7	12.8	14	11.8–14.2	13.4
1964	4	8.6–13.4	11.3	1	13.1	13.1	1	17.1	17.1
1963	1	13.8	13.8	..	..	..	6	15.9–18.8	17.7
1962	..	..	..	..	..	..	6	15.9–20.0	18.5
1961	..	..	..	1	18.2	18.2	2	20.4–20.6	20.5
Total	42	xxx	xxx	43	xxx	xxx	68	xxx	xxx

[1] Approximately 25,000 largemouth bass fry were stocked in alternate years in the 5-acre pond. Survival of these bass until they were netted for stocking at the end of their second summer approached 50 per cent. Golden shiners were used as forage fish.

ent contribution of stocked bass to the 1965 year class was probably associated with the small sample size or the increasing difficulty in recognizing marked fish with the passage of time. Bass stocked were of a smaller average size than native bass of the same age. However, by their fifth year of life, the stocked bass appeared to have reached the size attained by the native fish. It is not known whether increased competition for food and space, as a result of stocking the additional bass, was detrimental to the native bass population.

Considering the history of few angler returns for bass stocked in Nassau Lake, and the good native bass population, an annual stocking program is of questionable value. Largemouth bass stocked as fall yearlings could make a significant contribution to the bass population if the stocking coincided with the presence of a weak corresponding year class of native bass. In practice, this would be difficult to accomplish.

It is problematical whether a similar stocking program would be of value in a lake with a relatively small largemouth bass population. Stocking fall yearlings might be worthwhile if a lack of natural spawning success and/or a low survival rate among young-of-the-year and yearling bass were factors limiting the size of the population. Creel census information and comprehensive knowledge of the size and dynamics of the native bass population would be necessary to adequately evaluate such a stocking program.

EFFECT OF SEVERAL COOKING METHODS ON CONCENTRATION OF DDT RESIDUES IN LAKE TROUT AND COHO SALMON

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High concentrations of DDT [1,1-bis (p-chlorophenyl) 2,2,2,-trichloroethane] residues have been reported in lake trout (Burdick et al., 1964; Mack et al., 1964) and salmon (Anderson and Everhart, 1966; Duffy and O'Connell, 1968). Owing to the importance of these and other game and commercial fish as food, the effect of several typical methods of cooking coho salmon or lake trout on final residues of DDT commonly present in these fish was studied. Some data on the effect of various methods of cooking on DDT residues in fish (Anonymous, 1969; Reinert, 1970) and chickens (Ritchey et al., 1969) have been published. Loss of total DDT residues presumably occurs to the extent that fat or oil, in which the DDT is largely dissolved, is lost during cooking. Probably it also occurs to a degree by volatilization or codistillation with vaporized moisture.

The fish used in this study were mature lake trout (*Salvelinus namaycush*) from Cayuga Lake near Ithaca, N.Y. and Coho salmon (*Onchorhynchus kisutch*) from Lake Michigan. The fish were sectioned longitudinally from top to bottom. Corresponding lateral portions of each fish were taken for study. One portion was analyzed as the raw sample, and the corresponding lateral section was cooked and then analyzed.

The cooking methods chosen included baking, broiling and poaching according to typical recipes used in restaurants. The specific recipes, which were followed as closely as possible, are listed in Table 1.

Analysis of DDT residues was conducted as follows: The raw or cooked sections of fish were ground in a meatgrinder and thoroughly mixed. Then, 25 grams of the ground sample were blended with 70 milliliters of distilled acetone. The mixture was filtered and rinsed with acetone to give a total volume of 100 milliliters of filtrate and mixed .Five milliliters of the filtrate (approximately diluted with acetone) were shaken with 5 milliliters of distilled hexane and 90 milliliters of 2 per cent sodium sulfate solution. Up to 10 microliters of the upper hexane layer were injected into a gas chromatographic column equipped with an electron affinity detector.

The gas chromatographic column was borosilicate glass, U-shaped, 9 millimeters outside diameter and 6 feet long. The column packing was prepared by mixing equal weights of 10 per cent DC-200 on 100-120 mesh Gas Chrom Q and 15 per cent QF 1 on Gas Chrom Q. The other chromatographic operating parameters were identical to those described earlier (Gutenmann and Lisk, 1963).

The results of various methods of food preparation on the final residues of DDT in fish are given in Table 1. DDT residues in fish, as determined by electron affinity gas chromatography, are usually found to be present as DDT and its metabolites DDE [1,1-bis (p-chlorophenyl) 2,2-dichloroethylene] and DDD [1,1-bis (p-chlorophenyl) 2,2-dichloroethane]. DDT residues are expressed as the sum of the three compounds on a parts per million (milligrams of toxicant per kilogram of sample) basis. This method of reporting was chosen since the effect of cooking on the final determined concentration of each compound in the samples was very similar.

The most interesting general observation is that the residues in the cooked fish, as compared with those in the corresponding raw fish, appeared to increase or remain fairly constant in nearly all tests. Portions of the total residue of the toxicants present in the raw fish were, in the cooked fish, undoubtedly lost as fish oils were

Table 1. Effect of Various Cooking Methods on Final Residues of DDT in Lake Trout and Coho Salmon

Fish	Cooking method	Reference	DDT* residue in ppm	
			Raw	Cooked
salmon..	bake—en brochette	Beard (1954), p. 170	15.4	19.9
salmon..	bake—southern style (recipe file no. 10)	Anonymous (1963), p. 98	12.3	12.9
salmon..	broil	Beard (1954, p. 158	14.6	15.8
salmon..	broil	Beard (1954), p. 158	13.7	19.3
salmon..	broil—en brochette	Beard (1954), p. 170	15.4	17.0
salmon..	poach in bouillon	Beard (1954), p. 158	14.6	13.3
salmon	poach in bouillon	Beard (1954), p. 158	9.8	6.3
trout....	bake	Smith (1949), p. 235	17.4	19.7
trout....	broil—Rocky Mountain style (recipe file no. 11)	Anonymous (1963), p. 98	2.1	1.8
trout....	broil—Rocky Mountain style (recipe file no. 11)	Anonymous (1963), p. 98	1.7	1.4
trout....	broil—but without souffle sauce (recipe file no. 12)	Anonymous (1963), p. 98	1.4	1.5
trout....	broil—but without souffle sauce (recipe file no. 12)	Anonymous (1963), p. 98	16.9	20.0

*Sum of DDT, DDE and DDD.

cooked out or by direct vaporization of the compounds. These losses of DDT in fish have been estimated and reported (Anonymous, 1969; Reinert, 1970). The residue concentrations remaining in fish following cooking have not been reported, however. The data (Table 1) indicate that the remaining residues were concentrated in the cooked fish by dehydration to an extent which nullified the toxicant loss on a concentration basis. Probably due to individual differences in the fish, such as oil content, initial toxicant content, etc. and even variations in replicated cooking processes, no specific observations are apparent regarding the effectiveness of one cooking method compared with another in concentrating the residues. It was also considered that the initial toxicant concentration in any particular raw fish may have varied in the two sides. The residue concentrations of DDT, DDE and DDD were, therefore, determined in both sides of several raw fish. The variations in concentration of DDT (the sum of DDT, DDE and DDD) observed in corresponding left the right sides of the fish averaged about 1 ppm.

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FATE OF DUCK EGGS LAID IN GOOSE NESTS[1]

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During a survey of nesting Canada geese (*Branta canadensis*), from May 12 to 15, 1970 at the Wilson Hill Wildlife Management Area in St. Lawrence County (New York), 94 goose nests were found. Of these, four also contained one duck egg each, and one contained two duck eggs. The duck eggs were either mallard (*Anas platyrhynchos*) or black duck (*Anas rubripes*). Subsequent observations related to two of these nests.

One nest was observed on May 14 to contain six goose eggs and two duck eggs. On June 9, the goose was still incubating, but the six goose eggs present were not viable. Neither of the duck eggs were in the nest, but a duckling, either a mallard or a black duck, was in the water within 5 yards of the nest. The duckling was estimated to be between 7 and 12 days old according to the method of Gollop and Marshall (1954). No other ducks or ducklings were in the vicinity. Although the goose was apparently oblivious to the duckling, the duckling seemed attached either to the goose or to the area of the goose nest.

The second nest, which on May 14 contained six goose eggs and one duck egg, was empty by May 20. The goose eggs had hatched successfully. A duck egg was found 10 feet from the nest and had been opened, apparently by a crow. The membrane was present in the egg, and veins were visible in the membrane.

In both cases the duck eggs were viable, and all underwent development. In neither case did the presence of the duck eggs affect the behavior of the goose in regard to her clutch. Apparently in the first case the duck egg hatched, probably because the goose was detained on her own nonviable eggs, but the hatching of the duckling did not distract the goose from incubating her own eggs. In the second case it appears the duck egg was not completely developed when the goose eggs hatched and was abandoned when the goose brood left the nest.

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[1]A contribution of Federal Aid in Fish and Wildlife Restoration Project W-39-R.

STABILITY OF ROTENONE EMULSIONS

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In treating streams, rotenone is commonly introduced from a constant-flow device as a mixture of water and a 5 per cent commercial emulsifiable form of the poison. The device is set to run out in the desired time, the rotenone is added in an amount necessary to give the desired downstream concentration, and sufficient water is added to fill the container to a given volume.

On September 4, 1970, an attempt was made to treat a section of the Ten Mile River with 3.2 ppm Noxfish[1]. The stream-flow parameters required that 12,400 milliliters of Noxfish be dispensed into the stream over a period of 3 hours, 40 minutes. This volume was placed in a 5-gallon Mariotte bottle set to run out in the required time. Water was added to make a total volume of 19,000 milliliters. The resulting mixture, consisting of 65.3 per cent Noxfish and 34.7 per cent water, separated out into two distinct parts during the first hour. Subsequent bioassays indicated that rotenone concentrations were equivalent to 10 per cent Noxfish in the upper part (mainly water) and 93 per cent in the lower part (mainly Noxfish). In previous tests, using lower Noxfish: water ratios, the mixture in the bottle had always formed a stable emulsion upon stirring.

As a result of this experience, a series of tests was run on the stability of rotenone emulsions. An emulsion containing 25 per cent Noxfish and 75 per cent water was stable at the end of 24 hours. When the proportions were reversed, separation

TABLE 1. DEGREE OF SEPARATION OF VARIOUS EMULSIONS OF ROTENONE (AS NOXFISH) AND WATER AT DIFFERENT INTERVALS AFTER MIXING

Emulsion (in milliliters)		Volume of lower (Noxfish) part (in milliliters)		
Noxfish	Water	After 1 hour	After 5 hours	After 24 hours
35	65	0	trace	2
40	40	0	trace	20
50	50	trace	10	50

TABLE 2. DEGREE OF SEPARATION OF VARIOUS EMULSIONS OF ROTENONE (AS CHEM FISH REGULAR) AND WATER AT DIFFERENT INTERVALS AFTER MIXING

Emulsion (in milliliters)		Volume of upper (water) part	
Chem Fish Regular	Water	After 1 hour	After 17 hours
25	75	60	75
35	65	25	65
40	60	15	60
50	50	1	15
75	25	trace	25

[1]A commercial rotenone product of S. B. Penick and Company, 100 Church St., New York.

began at 45 minutes and was nearly complete at the end of the first hour. Intermediate ratios exhibited varying degrees of separation (Table 1). It seems likely that, at 35 and 40 per cent Noxfish, the mild agitation of air bubbling through the inlet tube of the Mariotte bottle would prevent separation.

Chem Fish Regular[2] formed much less stable emulsions than Noxfish. Moreover, the character of the emulsion was different. At concentrations between 25 and 75 per cent, water appeared to behave as the dispersed part and to separate out of the emulsion at the top. The more dilute emulsions separated most quickly (Table 2).

These results indicate that Chem Fish Regular should not be diluted with water before introduction into a stream and that stock emulsions containing more than 40 per cent Noxfish should not be used. In the Ten Mile River test, separation would not have occurred if a 13-gallon bottle had been used in place of the 5-gallon bottle. In some situations the introduction of rotenone could probably be facilitated by using a diluting agent other than water.

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[2]A commercial rotenone product of Chemical Insecticide Corp., Whitman Ave., Metuchen, New Jersey.

A RECORD-SIZED SHORTNOSE STURGEON FROM THE HUDSON RIVER

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During an ecological study[2] of the Hudson River (from Tappan Zee Bridge to Bear Mountain Bridge) a record-sized shortnose sturgeon (*Acipenser brevirostrum*) was collected near Buchanan (N.Y.) on January 29, 1970. At the time of capture, it measured 932 millimeters in total length (826 millimeters in fork length) and had a girth of 398 millimeters. Laboratory examination revealed that it was a mature female weighing 4,994 grams (about 11 pounds) and had 941 grams of eggs. Based on a $\frac{1}{16}$ random sample from the entire ovary, the total number of eggs was estimated to be 75,728.

The sturgeon was collected in a 25-foot semiballoon bottom trawl during a 7-minute tow at a depth of 50 feet. Biologists tried to revive and release the specimen, but were unsuccessful.[3] River temperature was 33.0° F. on the surface and 32.5° F. on the bottom, salinity was 0.8 ppt and 1.4 ppt, respectively, and dissolved oxygen was 8.5 ppm from surface to bottom. Bottom sediment in this area was characterized by black silt with cinders. Other species caught in the trawl were Atlantic sturgeon (*A. oxyrhynchus*), Atlantic tomcod (*Microgadus tomcod*), white perch (*Morone americana*), striped bass (*M. saxatilis*) and hogchoker (*Trinectes maculatus*).

This specimen appears to be a new record size for the Hudson River, the largest previously reported (Curran and Ries, 1937) being a female that measured 34.8 inches (884 millimeters) in total length and weighed 8 pounds 15 ounces (4,054 grams). The largest shortnose sturgeon on record was a female collected from the Connecticut River (Vladykov and Greeley, 1963) that measured 39.5 inches (1,003 millimeters) in total length, or 899 millimeters in fork length. LeSueur described a female 33 inches (838 millimeters) in fork length from the Delaware River (Ryder, 1890).

During this study, Atlantic sturgeon were collected occasionally in bottom trawls and gill nets, but shortnose sturgeon were rare. Shortnose sturgeon have been reported from New Brunswick (Canada) to Florida. Greeley (1937) reported that they spawn in April in the Hudson River.

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[1] Raytheon Company, P.O. Box 360, Portsmouth, R.I. 02871.

[2] Conducted from June 1969 to December 1970 for the Consolidated Edison Company.

[3] This specimen has been deposited in the collection of the American Museum of Natural History (Cat. No. 29822).